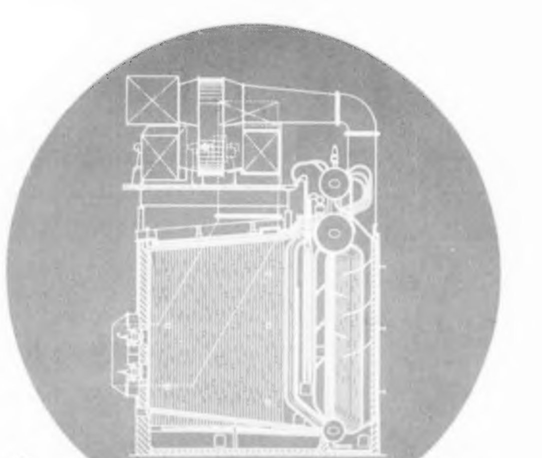
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Hold for 1954

January 1953

The Highgrove Steam Plant of the California Electric Power Co. is a representative 1952 outdoor station.



1. VU-50 Unit, installed in a Petroleum Refinery. Burning natural gas and oil, the unit has a capacity of 260,000 lb of steam per hr at an operating pressure of 400 psi and steam temperature of 660 F.

one VU is only the beginning

It seems that the story *never ends* with the purchase of the first Vertical-Unit Boiler. Company after company has installed a VU unit . . . liked it . . . and then bought another — and another — and often another. This is true in every branch of industry, but the three typical examples described below and illustrated by the accompanying drawings will serve to illustrate the point.

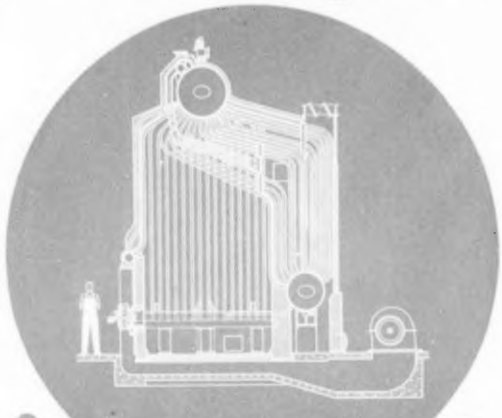
A Petroleum Refinery (1) ordered its first Vertical-Unit Boiler in 1937. A second VU Unit was installed in 1941, and a third in 1950. For another of its plants, two VU Units were ordered in 1942; a third, in 1947.

An Automobile Company (2) installed its first two VU Units in 1947. Two more were ordered for another of its plants in 1948; then three more units for a third plant in 1949 and two more for still another plant in 1950.

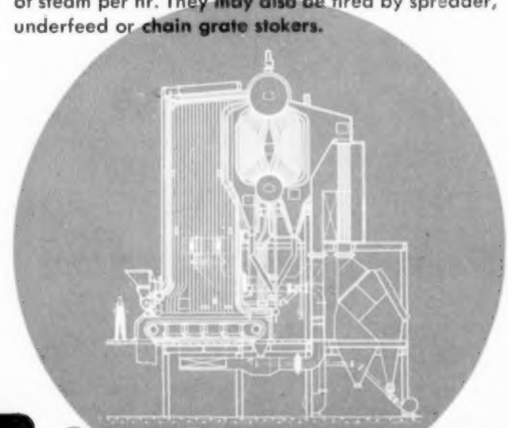
A Chemical Company (3) ordered two VU Boilers in 1939. In 1946, five more were ordered for three of their other plants. In 1949, two more were ordered for one of these same plants, and in 1950 two more units for a fifth plant. In 1951, seven more VU Units were ordered for still another plant — eighteen units for six plants in twelve years!

• • •

And so it goes — in all sections of the country — companies representing every type of industry . . . paper, food, mining and metal working, brewing, rayon, aircraft — and many others in addition to the examples pictured here . . . ordering and reordering VU Boilers. There must be a reason — and there is. It's lower steam costs and top reliability. These companies have found *through experience* what they can expect in economy and performance when they buy VU Boilers.



2. VU-10 Unit, one of three duplicates installed in an automobile plant. It is fired with oil or gas. VU-10 Boilers range in capacity from 10,000 to 60,000 lb of steam per hr. They may also be fired by spreader, underfeed or chain grate stokers.



3. VU-40 Unit, one of seven, now being installed in a Chemical Plant. These boilers will be fired with C-E Spreader Stokers (continuous discharge type). The capacity of each is 60,000 lb of steam per hr at an operating pressure of 325 psi; no superheat.

C-E

COMBUSTION ENGINEERING-SUPERHEATER, INC.

B-639A

200 MADISON AVENUE, NEW YORK 16, N. Y.

ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

COMBUSTION

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Feature Articles

Editorials

Departments

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GERALD S. CARRICK
Business Manager

ALFRED D. BLAKE
Editor

CARL Ç. UDELL
Circulation Manager

GLENN R. FRYLING
Assistant Editor

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COMBUSTION

Editorials

Common Sense—A Redefinition

Treasures from some of the intellectually stimulating papers presented at the Centennial of Engineering, held in Chicago last September, are still coming to light. The December issue of "The Journal of Engineering Education" included six papers presented at the ASEE Centennial Symposium on Engineering Education and Training. From one of these, "The Engineer and the Scientist" by W. F. G. Swann, director of the Bartol Research Foundation of the Franklin Institute, the following excerpts merit serious reflection:

"The time is coming when the engineer will find that the sharpening of his old tools is not sufficient for his task. He must acquire new and strange tools, tools which seem antagonistic to his common sense. But common sense is a curious attribute. In its proper domain, it is a jewel of priceless value, but when strongly entrenched in any realm, it can impede progress. Fortunately, it is a changeable kind of thing, and it will happen in the future, as it has in the past, that the common sense of the past is the nonsense of today, and the apparent nonsense of today is the common sense of the future. It is for the young engineers, or at least for those of them who are concerned with some of the most interesting aspects of future developments, to attune themselves to the common sense which is to come, that they may walk with the same security under its guidance as their predecessors have walked under the guidance of the common sense of their day."

The beginning of a new year may represent an occasion for a few hazy recollections of the old and some fleeting resolutions for the future, or more constructively, it may be a time for re-evaluation and reaffirmation. Dr. Swann's redefinition of common sense belongs in the latter category.

An Important Survey

The Twelfth Semi-Annual Electric Power Survey by the Edison Electric Institute is now available. Published in December, it deals with the electric power situation, both public and private, as of early October, with particular reference to future capabilities, planned expansion, estimated peaks, delivery schedules and manufacturing capacity for the production of power generating equipment. The report represents the findings of a committee of the E.E.I. in collaboration with power area representatives of the electric power systems and manufacturers of heavy power equipment. As such it offers a comprehensive and authentic picture of the power situation.

This series of studies, which was initiated early in the postwar period, became increasingly important with advancement of the Defense Program which imposed unprecedented demands on materials supply and power. Although these demands progressively slowed up the fulfillment of scheduled deliveries, it was the steel strike of last summer, with its numerous secondary effects, that greatly complicated the situation and made necessary a revision of estimates contained in the previous Survey of last April. This applied to both total capability and decreased peak demand.

It became apparent that there had been a cumulative slippage in deliveries for scheduled programs of some three million kilowatts of capability during the preceding eighteen months, although seventy new generating units were expected to go into service during the last three months of 1952, making for an increase of approximately nine per cent in total capability for the year.

The vast power demands of the Atomic Energy Program, to meet which a number of huge public and private generating stations are now being laid down, will further tax the materials supply inasmuch as they carry the highest priority. In view of this, the Survey committee asserts that power expansion of the electric utilities needs special assistance from the defense agencies. It concludes that, although little can be done to help the 1953 program, a large part of the deficiency can be made up by the end of 1954.

Evaluating Experimental Data

Use of the slide rule becomes almost second nature to the engineering student who is required to solve innumerable formal problems and to perform many laboratory experiments. All too often he comes to accept quantitative values without questioning their origin and their inherent accuracy and reliability. However, his faith in numbers and the results of calculations is not always merited by the certainty of the data with which he is working.

This rather naive attitude toward the value and exactness of numerical quantities often carries over into engineering practice. Much experimental work, together with related calculations, is carried out without due regard to precision of measurement and sources of error. Paradoxically, some of the most precise data which require extreme care for their collection may be employed indiscriminantly. The result may be a computed answer of much less reliability than some of the original experimental measurements.

How incongruities of this sort may be avoided is explained in an article by S. J. Kline and F. A. McClintock appearing in the January issue of "Mechanical Engineering." Under the title, "Describing Uncertainties in Single-Sample Experiments," the authors cite an example involving measurement of velocity of an air stream with a pitot tube. They show how improvements in the precision of measurement of certain variables contribute to improving the overall accuracy of the results.

Aerial view of Chillicothe plant

Power and Steam Generation at Chillicothe Division of The Mead Corporation

By WALTER H. HALL
The Mead Corporation

LOCATED in the wooded hills of South Central Ohio is the city of Chillicothe, a pioneer settlement and capital of the old Northwest Territory and the first capital of the State of Ohio. Almost from the first settlement the city became a center of paper manufacture. The first of a number of paper mills was established just outside the present city limits in 1812. From that date paper making has been carried on continuously in the city. Today two large modern mills are in operation.

The older and larger of these mills, the subject of this article, is known today as the Chillicothe Division of The Mead Corporation. It began operations in 1848 in a tiny building on the site of the present mill. In a little over a hundred years it has grown from a plant employing twelve people to produce a few hundred pounds of paper daily to a plant employing nearly 2000 workers turning out six hundred tons of high-grade printing papers every working day.

Since production was first started at this plant in 1848, a wide variety of equipment has been employed for the purposes of steam and power generation and for chemical recovery. This article interestingly traces the evolution of equipment that has been used and describes the recent installation of a modern chemical recovery unit and a double-automatic-extraction mixed-pressure condensing turbine-generator operating at 850 psig, 825 F.

Evolution of Power Generation

Power has always been a major item in the production of paper. When the mill was first constructed power was supplied by a water wheel operated by the flow of a neighboring creek. In 1858 after floods had destroyed the dam and head race of the water power installation for the second time in a ten-year period, a boiler and steam engine were installed to replace the water wheel. Since that time steam-generated power has been the only source of mill power.

Development of the mill power system closely paralleled the progress in the art of power generation. By the turn of the century numerous small steam engines and boilers scattered through the mill had been supplanted by a central boiler plant and large compound condensing steam engines driving the mill through line-shaft and belt drives. About the same time electrical power distribution made its appearance with the installa-

tion of an engine-driven generator to supply current for lights and a few small motors.

In 1916 the steam turbine entered the picture. Along with a new boiler plant employing stoker-fired water-tube boilers a 750-kw turbo-generator was installed. After more than 40 years of service this turbine still stands on its original foundation and is in operating condition. Following the successful operation of the first turbine, two additional turbines of 2000 and 3000-kw capacity were installed in rapid succession and most of the old steam engines were replaced with electric motors.

In 1926 a new power plant was constructed to provide power to electrify the last of the engine-driven equipment and to supply power for further expansion. This plant was one of the pioneer industrial power plants built to burn pulverized coal. When completed it consisted of four Stirling-type water-tube boilers fired by a Lopulco bin system for burning pulverized coal and three condensing-extraction turbines with a total capacity of 9500 kw. Initial steam conditions were 200 psig, 100 deg F superheat with extraction at 20 psig for process and heating steam.

The boiler plant was typical of bin-fired pulverized fuel installations of the day. Furnaces were largely of air-cooled refractory construction with only a small amount of waterwall surface on the side and rear walls, together with screen tubes just above the furnace floor. Burners were arranged to fire vertically downward through the furnace roof. The basic soundness of this early pulverized-fuel furnace design is proved by the fact that after twenty-five years service this equipment is still operated continuously at loads in excess of designed capacity.

In 1929 expansion of the mill again required increased steam and power generating facilities. Accordingly a new power house was built in an area adjoining the new additions to production equipment where adequate space for future expansion was available. The 1929 expansion included two 70,000 lb per hr Stirling boilers and a 3500-kw single-extraction condensing turbo-generator.

Based on the success of the earlier pulverized fuel installation pulverized fuel was again specified. However, direct firing had developed to the point that the new boilers were each fired by a single pulverizer. Turbulent-type horizontal burners firing an almost completely water-cooled furnace were employed. Steam pressure was boosted to 400 psig, with a total temperature of 650 deg F.

In 1937 still further growth required additional power capacity. Accordingly a third boiler duplicating the two previous 70,000 lb per hr units was installed. The only major change from the two previous boilers was the installation of two pulverizers of more modern design and greater capacity to handle low-grindability, high-moisture fuels. An additional 7500-kw condensing-extraction turbo-generator was also installed as part of this expansion program.

Early Chemical Recovery Units

The Chillicothe soda-pulp mill of The Mead Corporation has followed a pattern of development similar to that of the power plant. Prior to 1876 raw material for paper manufacture had been rags and straw. In that year the management of the mill was so impressed with a public demonstration of the soda process at the Centennial Exposition in Philadelphia that a pulp mill was errected in Chillicothe, one of the first chemical pulp mills to be built west of the Alleghenies.

From the start soda recovery has been a vital part of the pulp-mill operation. In the early days of soda-pulp manufacture the American alkali industry was nonexistent and all soda ash for makeup of chemical losses was imported from Europe. The recovery process was exactly what the name implied—chemical recovery. Recovery of heat was ignored; evaporation was carried out with direct heat with very crude apparatus.

In the early 1900's the multiple-effect steam evaporator was adopted from the sugar industry, and the rotary incinerator with a crude waste heat boiler was developed. These improvements greatly reduced the amount of supplementary heat required to recover the soda, and the process reached a point where the combustion of the waste carbonaceous material in the liquor supplied just about enough heat for evaporation and recovery of the soda salts.

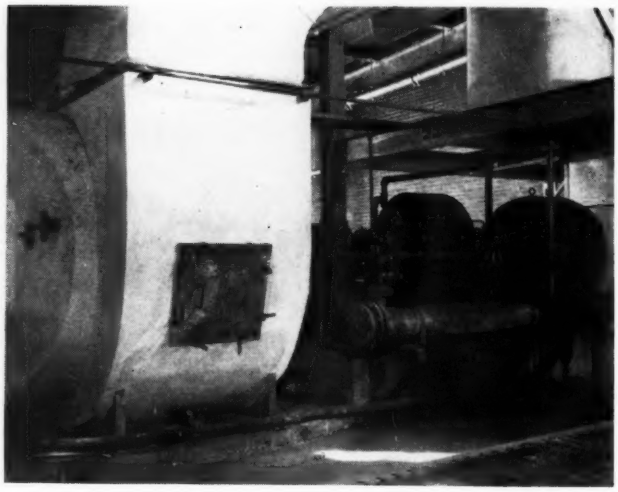
In 1929 with the expansion of the plant, a new pulp mill was constructed. With this mill a radical forward step was taken in recovery with the installation of two Wagner furnaces for soda recovery. The Wagner furnace was one of the pioneer designs of recovery unit employing the basic principles of modern recovery practice. This unit consisted of a partially water-cooled furnace into which concentrated liquor was sprayed for suspension burning, with complete combustion and recovery of the soda as molten smelt; an efficient waste heat boiler, with soot blowers to maintain heat absorbing surfaces in reasonably clean condition; and an electrostatic precipitator to recover the extremely fine soda from the flue gases. For the first time the recovery process had become more than chemical recovery and a significant contribution of recovery heat from combustion of the organic solids in the waste liquor was delivered to the mill steam system.

Conditions at the End of World War II

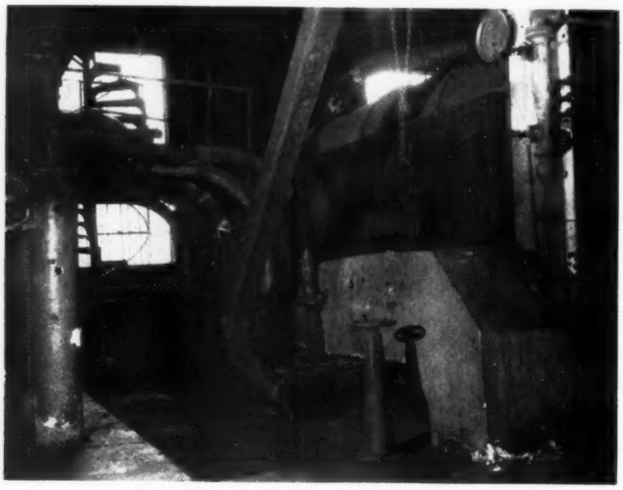
When World War II ended The Mead Corporation was, like all industrial corporations, faced with many problems. Two were especially important. Pulp mill capacity had not been enlarged recently, but paper production had increased steadily. Thus the mill was becoming increasingly dependent on the outside supplies of pulp.

Likewise the power plant was becoming less efficient and because of these conditions necessary increases in capacity had been impossible. Steady increases in mill load had resulted in operation of electric generating equipment at a continuous overload, boiler loads had risen to the point where it was necessary to purchase premium fuel rather than the most economical available coals to obtain satisfactory operation, and the balance between power requirements and process steam demands had reached a point where power generated by straight condensing operation was becoming excessive.

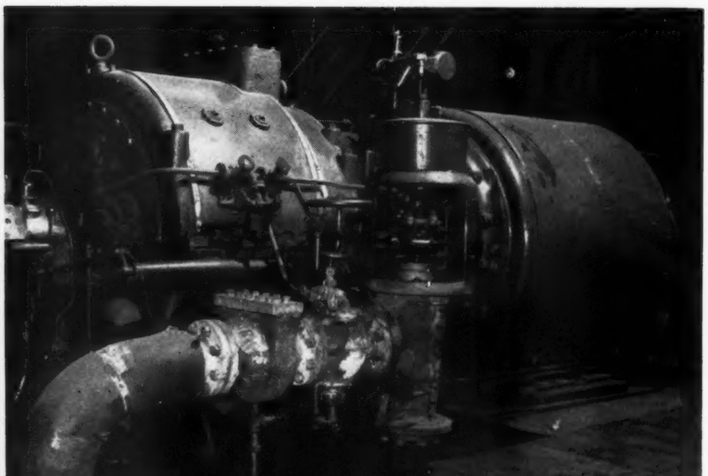
Studies of the pulp requirements of the mill and existing equipment indicated that the most economical solution of the problem was a new pulp mill to completely replace all existing facilities. Power studies of various combinations of equipment and various operating steam pressures established that it was most economical to



Induced-draft fan and fluid drive as applied to the recovery unit



View showing Lopulco feeders and burners on first pulverized-coal boiler installed in 1926



First steam turbine installed by Mead Corp. in 1916; rated at 750 kw; still in operating condition

meet load growth by expansion of the power plant rather than by purchased power, that the older 200-psig steam plant should be retired as rapidly as possible, and that a steam condition of 850 psig, 825 F at the turbine throttle would be most economical. Both the pulp mill and power plant expansion were laid out as a series of steps which could be carried out as funds were available, each step fitting into a long-term program while at the same time solving an immediate problem and showing a return on the investment.

Expansion Program

After all analyses had been completed it was apparent that the first step in the combined program should be the installation of a new recovery boiler, a new multiple-effect steam evaporator and a new high-pressure turbo-generator. Accordingly in 1950 orders were placed for a new recovery unit, a new multiple-effect evaporator and a new turbo-generator set.

The recovery unit furnished by Combustion Engineering-Superheater, Inc., is rated to burn the liquor from a daily production of 175 tons of unbleached soda pulp, delivering at rated capacity 71,250 lb of steam per hr at 875 psig, 825 F. Under these conditions the unit has a capacity to burn 525,000 lb of dry solids per 24 hours. Design of the boiler is typical of the general practice of modern recovery units with a completely water-cooled furnace, a two-drum vertical bent-tube boiler designed particularly for ease in keeping heating surface free of soda deposits, an integral economizer and a cascade evaporator employing two wheels in series.

Due to the high steam temperature for a recovery unit, the space required for a parallel flow superheater of adequate surface required the elimination of the front drum frequently employed in boilers of this type. Consequently waterwall risers are carried over the top of the superheater into the main drum. Preheated air is supplied to the unit by a steam air heater. The primary bank of heater elements is supplied with 30-psig steam and the secondary elements are operated on 350-psig saturated steam. This steam is supplied through a reducing and desuperheating station from 400 psig steam service.

Induced draft is supplied by a synchronous-motor-driven fan with a hydraulic coupling to permit fan capacity to be controlled by speed variation. A Research Corporation vertical flow electrostatic precipitator recovers approximately 95 per cent of the soda dust carried away by the flue gases. This precipitator is of the wet-bottom type arranged so that the collected dust dislodged from the collecting electrodes is immediately dissolved in the water makeup on its way to the smelt dissolving tank. Provision has also been made so that by very simple piping changes black liquor on its way to the cascade evaporator can be used in place of water. The precipitator is also unusual in that it is installed ahead of the I.D. fan and operates under negative pressure instead of being installed after the I.D. fan as is usual recovery boiler practice. This arrangement applied to a vertical-flow precipitator saves space, simplifies ductwork and largely eliminates dust deposits and necessity for frequent cleaning of the I.D. fan.

No gas bypass around the precipitator has been provided as location of the pulp mill close to a residential

area makes operation of the recovery unit without thorough gas cleaning almost impossible. Dust from the boiler and economizer passes is returned to the cascade evaporator and recycled with the incoming liquor to reburn any coarse carbon particles carried over from the furnace.

Soot blowing is accomplished by a combination of long retractable Diamond soot blowers operating on 400-psig steam to clean the hot zones of the boiler and superheater and air puff soot blowers in the cooler zones. Due to space limitations necessitated by location of the recovery unit within existing building lines, the retractable blowers are installed in pairs on opposite sides of the unit so that in the retracted position the units are within the available building width. Air for the air puff units is supplied by a two-stage motor-driven Ingersoll-Rand air compressor designed to supply blowing air at 350 psig but normally operated at 275 psig.

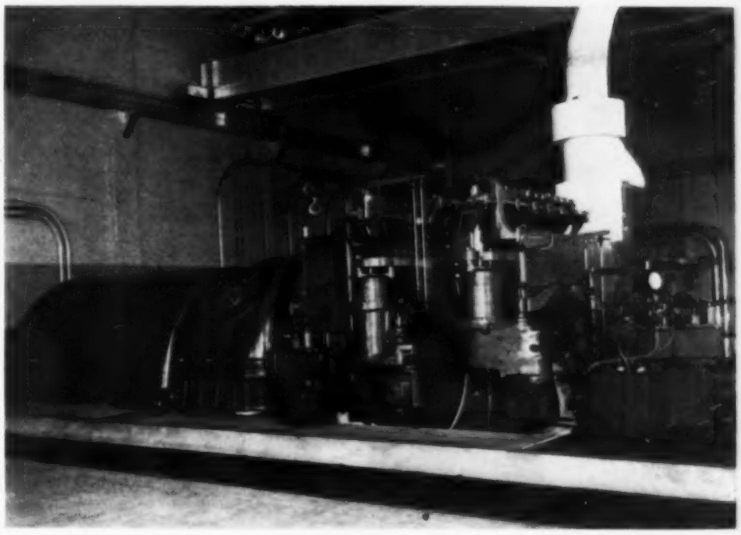
Inasmuch as steam for operating the retractable blowers is supplied at 400 psig from the existing 400 psig steam system rather than directly from the boiler drum, a hazard exists to personnel because it is possible to operate the steam blowers while the unit is off the line for inspection or repairs. To minimize this danger an interlock valve was provided. This is a single-seated control valve held normally closed by the pressure of the steam in the 400 psig line. Opening force is supplied by a piston in a cylinder connected by a pressure line to the boiler drum. Thus the valve cannot open to admit steam to the soot blower system unless the boiler drum pressure is in excess of the available pressure in the supply to the soot blowers.

Controls and Auxiliaries for Recovery Boiler

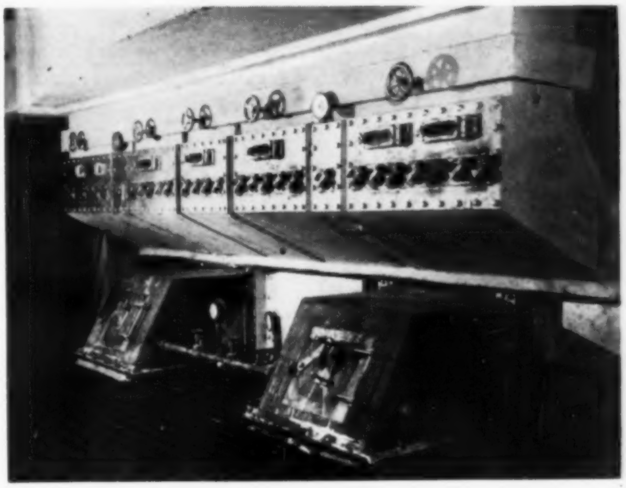
While a recovery boiler does not lend itself to full automatic control, a special effort was made to arrange for a maximum of automatic control and to locate the manual controls so that they could be operated either directly from the main control panel or from stations on the main operating floor adjacent to the control panel. Indicating gages are provided on the panel for all significant pressure and draft points, and recorders for flows and temperature. Automatic control is provided for liquor temperature, cascade liquor level, furnace draft, dissolving tank level, feedwater level, and feed-pump discharge pressure. Air flow is controlled by remote manual control from the panel. Liquor feed rate is adjusted by remote speed control of the liquor feed pumps operated from a separate motor-control panel located adjacent to the main-control panel.

An entirely separate feedwater system arranged to feed 100 per cent condensate was installed. Condensate is supplied to a 225,000 lb per hr deaerator operating at about 3 psig having a 12-min. capacity storage tank. Two 110,000 lb per hr 1150-psig, 8-stage barrel-type Pacific boiler feed pumps are driven by 260-hp Westinghouse turbines at 3600 rpm. Each pump is provided with a low-flow bypass actuated automatically from contacts in the feedwater flowmeters.

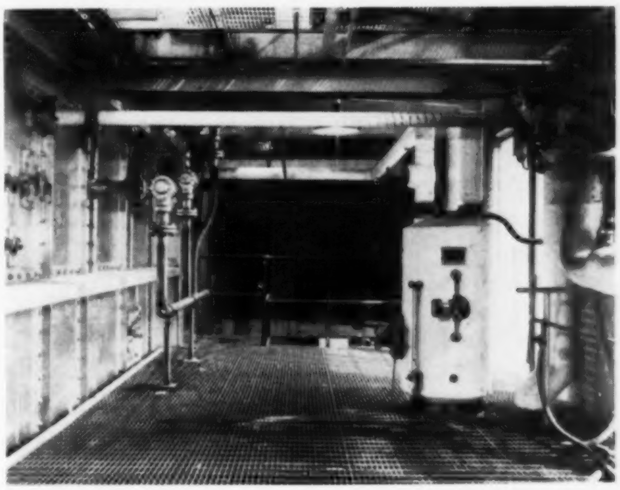
A closed feedwater heater is installed between the feed-pump discharge and the economizer inlet. This heater supplied with 30-psig steam raises the feedwater temperature from 215 F to 270 F. This heater also serves as a flash condenser and cooler for the condensate trapped from the 350-psig section of the steam air heater.



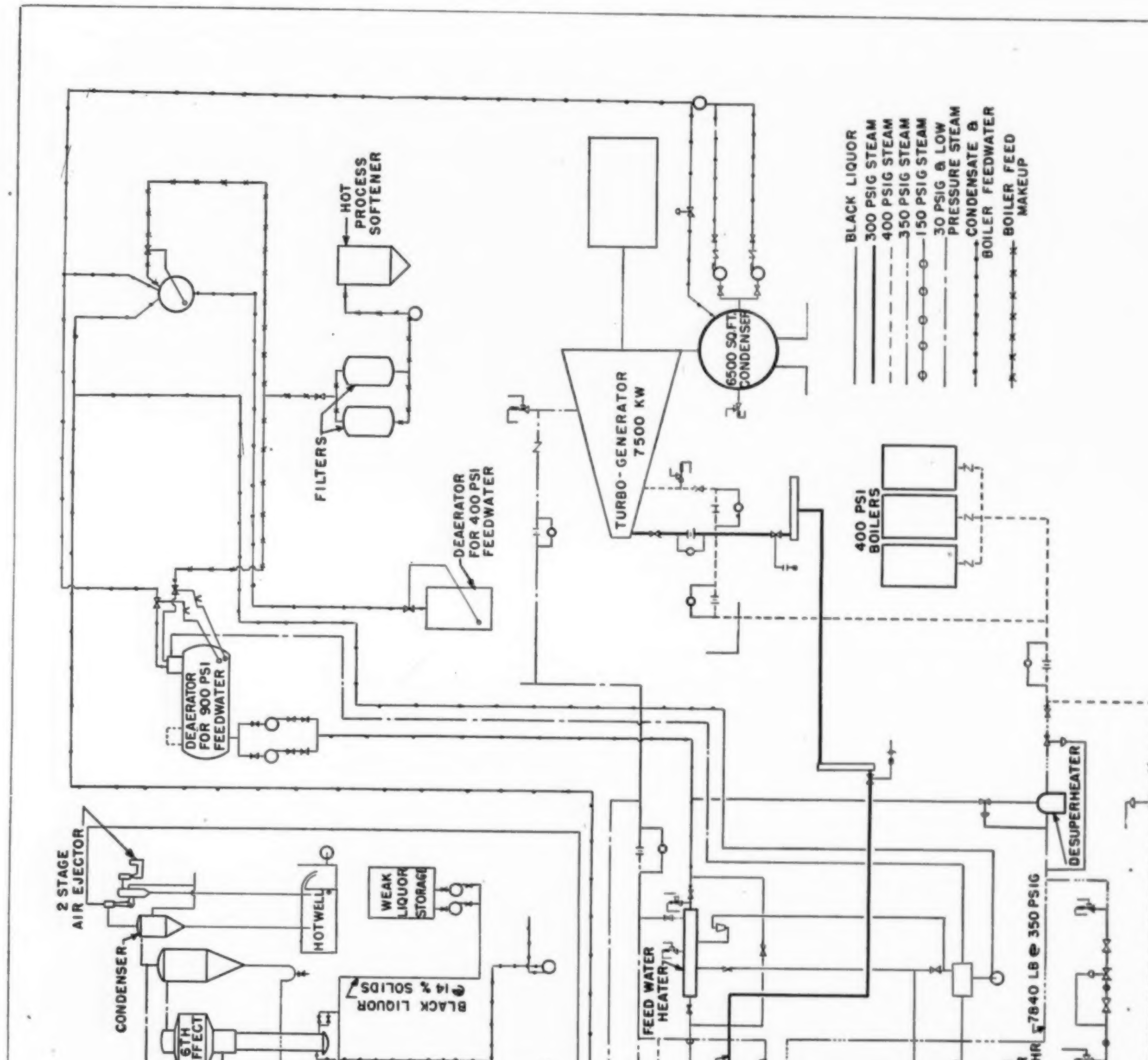
View of new 7500-kw, 850-psig turbine showing governing mechanism



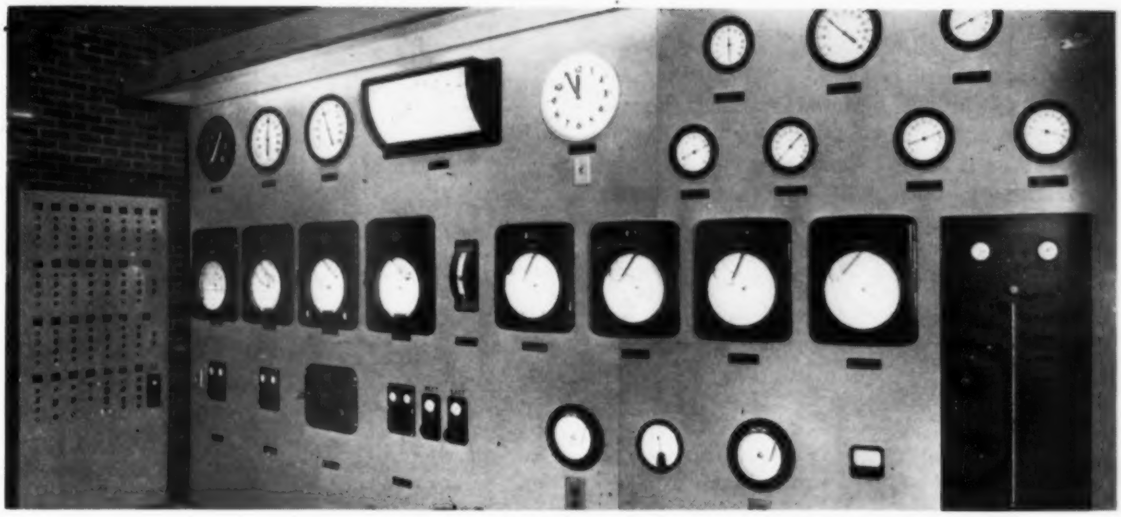
View of recovery unit showing primary air ports and liquor spout housings



Side of recovery unit showing retractable and air-puff soot blower installation; continuous blowoff flash tank at right



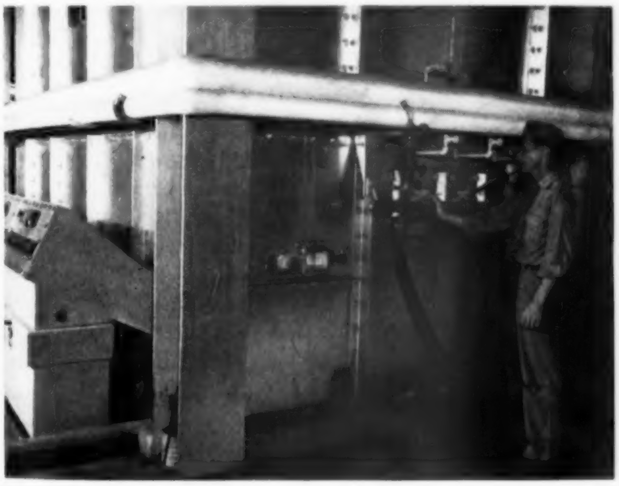
Schematic arrangement of recent power expansion program, showing integration of chemical recovery unit



Recovery control panel showing instruments and controls for steam, air and feedwater; also motor-control panel and instruments and controls for black liquor and for soot blowing

All condensate is trapped into a condensate-collecting tank on the basement floor of the recovery boiler room and thence pumped back to the deaerator. Flash steam from the collecting tank is vented to the deaerator.

A continuous blowoff system is provided. The blowdown is first flashed at 30 psig. From this tank the blowdown passes to a flash tank serving the 400-psig boilers where it is flashed to the deaerator at approximately 3 psig and then through a heat exchanger cooled by makeup water, thence to the sewer.



Main operating floor of recovery unit showing black liquor burners; secondary air ports at extreme left

Adjustable stroke pumps are provided to feed phosphate direct to the drum and sulfite and caustic to the feedwater leaving the deaerator.

A 4000-lb pushbutton-operated combination freight and passenger elevator is provided to serve all working floor levels to handle both personnel and lighter parts and maintenance equipment. A five-ton electric hoist over a hatchway at the rear of the boiler is provided to handle heavy parts to all floors, up to and including the induced-draft-fan level.

Multiple-Effect Evaporator

The new multiple-effect evaporator, a six-body sextuple-effect Goslin-Birmingham unit, is installed outdoors alongside of the recovery boiler building. The evaporator is of the long-tube film type, with a stainless steel first effect. It is provided with a split feed of weak liquor to the fifth and sixth effects and for two-pass operation of the first or concentrated liquor effect. Steam supply is taken from the 30-psig extraction steam system. Vapor from the last effect is condensed in a barometric condenser equipped with a two-stage steam-jet ejector. Warm water from the condenser hotwell is reclaimed and used for pulp washing.

The evaporator is equipped with automatic control for all functions except evaporating rate, which is adjustable manually to match the quantity of liquor available from the pulp mill.

Turbine-Generator and Related Equipment

The new turbine was selected after studies of various types of machines. The problem initially involved the maximum possible amount of generating capacity utilizing a limited and variable amount of high pressure steam, plus some surplus capacity in coal-fired 400-psig boilers. The machine finally selected was a General Electric 7500-kw double-automatic-extraction mixed-pressure condensing unit with a 9375-kva, three-phase, 60-cycle, 13,800-volt air-cooled generator and direct-connected exciter. The turbine exhausts into a 6500-sq-ft. Ross surface condenser.

High pressure admission is at 850 psig and 825 F. Steam may be either admitted or extracted at 400 psig and extracted at 30 to 40 psig. The condenser is designed to maintain 2-in. Hg absolute pressure at the turbine exhaust with full load straight condensing.

At present this turbine operates with initial pressure control of the 850-psig inlet valves to adjust steam flow at this pressure automatically to suit the recovery boiler output. The speed governor operates to control flow through the 400-psig valves and through the lower pressure section to the condenser. Depending on electrical

load and the available steam from the recovery boiler, the turbine may either admit or extract at the 400-psig opening under full automatic control.

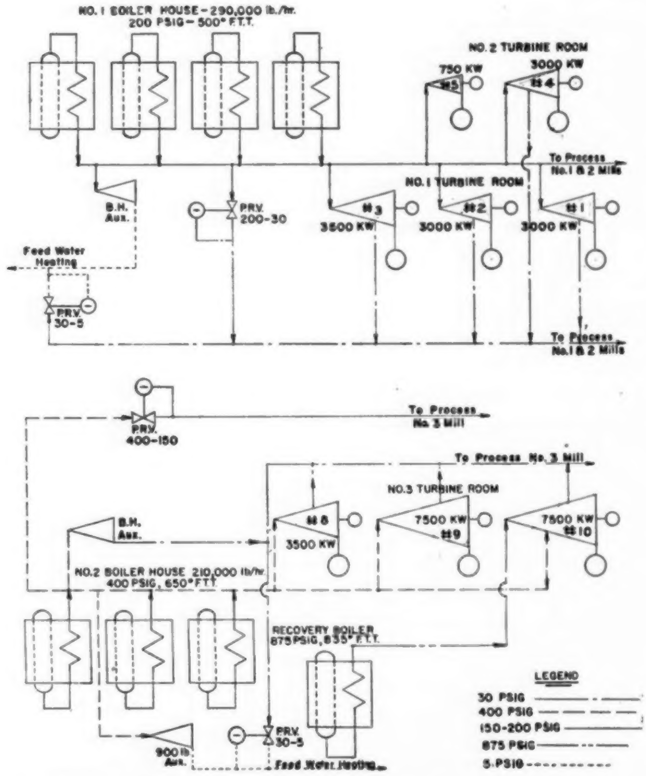
When an additional 850-psig boiler is installed, the turbine will operate as a conventional double-automatic-extraction machine with the 900-psig inlet valves under speed-governor control and the 400 psig and 30 psig extraction automatically controlled by the pressure in those systems.

The condenser is a two-pass divided-water-box unit taking circulating water from a well system and discharging warm water to process uses in the mill.

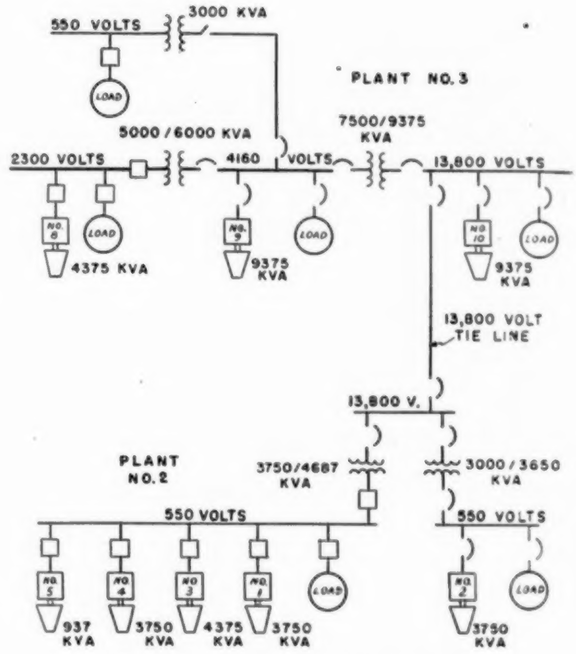
All piping for both the boiler and turbine installation was welded so far as possible. High-pressure steam lines were designed for 900 psig and 900 F to provide a safe margin for unavoidable temperature and pressure variations. All piping for this service was shop fabricated from 1 per cent chrome, $^1/_2$ per cent molybdenum tubing. Valves are of the pressure-sealed design, with motor operation of larger valves. In this system all flanged joints with the exception of the turbine steam strainer and throttle valve were eliminated. The high-pressure boiler-feed piping was similarly welded except for flanged joints at the boiler-feed-pump outlets and connections to the closed heater. Piping for lower pressures was generally all welded except for valves which are bolted bonnet flanged end pattern.

Electrical Distribution System

A major revision of electrical distribution has been required to limit short circuit currents due to increased generator capacity. The original power plant generated 600-volt power. Later expansions were at 2300 volts and 4160-volts. However, studies proved that the highest of these voltages was inadequate to meet future needs so



Simplified overall flow diagram for entire plant



Existing electrical power system

13,800 volts was adopted for the new generator. Bus-tie transformers have been provided to tie the new generator into the existing system but plans have been made for eventual elimination of all generation at lower voltages with distribution from the 13,800-volt bus to unit substations supplying power at either 2300 or 550 volts.

Plant Performance

Performance of the entire plant has been extremely satisfactory. Approximately 75 tons of coal per day have been saved through operation of the new equipment together with substantial improvement in soda recovery and decreases in operating labor and maintenance.

All engineering for the project was handled by The Mead Corporation Engineering Staff. Construction of buildings, installation of the turbine, and all electrical work was handled by Company construction forces. Erection of the boiler and high pressure piping was done by outside contractors.

List of Principal Equipment Suppliers

Recovery boiler	Combustion Engineering-Superheater
Cascade evaporator	D. J. Murray Mfg. Co.
Precipitator	Research Corp.
Fans	American Blower Co.
Pumps	Goulds Pumps, Worthington Corp.
Motors	General Electric, Reliance, Elliott, Electric Machinery
Air compressors	Ingersoll-Rand, Nash Engineering
Feed pumps	Pacific Pumps
Feed-pump drive turbines	Westinghouse Electric Corp.
Deaerator	Cochrane Corp.
Multiple-effect evaporator	Goslin-Birmingham Mfg. Co.
Turbo-generator	General Electric Co.
Condenser	Ross Heater & Mfg. Co.
Transformers & switchgear	General Electric Co.
Meters & controls	Bailey Meter Co., Foxboro Co.
Pipe fabrication	Crane Co.
Valves	Crane Co., Edward Valves
Heat insulation	Johns-Manville
Boiler erection	Oberle-Jordre Co.
Erection of high pressure piping	Huffman-Wolfe Co.
Refractories	United Refractory Constr. Co.

POWER ACTIVITY IN 1952

CONTINUED expansion in both capacity and sales by electric utilities; contracts for huge power installation to meet the demands of atomic energy projects; the ever-increasing size of boilers and turbines; and the unprecedented orders for large high-pressure, high-temperature controlled (forced) circulation boilers, making a total of 30 now building or on order, highlighted the power record of 1952. Notable also was the increasing number of outdoor or semi-outdoor plants regardless of latitude; the widespread adoption of reheat, together with high steam conditions; the extension of centralized control; advancement in the commercial application of gas turbines of moderate capacity for electric generation; and reported progress toward the utilization of nuclear energy for power.

Although final figures are not available at this writing, additions to overall central station capacity appear to have fallen short by about three million kilowatts of the goal originally set by the Defense Electric Power Administration, which is charged with planning for an adequate electric power supply. Last March that agency fixed 32 million kilowatts as the goal for new capacity to be added during the years 1952-1954. With approximately 75 million kilowatts installed in central stations at the end of 1951, this would have made a total of 107 million kilowatts by the end of that three-year period. Last summer this goal was extended to 116 million kilowatts by the end of 1955.

Effect of Materials Situation on Deliveries

Although material shortages have been existent since initiation of the defense program, and resulted in slippages in expected equipment deliveries, the two months steel strike greatly aggravated the situation. This was not only during the strike when virtually no steel was obtainable for power plant work, but also during the subsequent recovery period when it became necessary to divert steel to certain critical defense industries. According to the DEPA, the cumulative effect of delays resulting from the steel strike superimposed on prior delays is expected to cause delays in in-service dates of from two to six months. It further expressed the opinion that the setback to the power program will not be completely made up before 1955.

Besides the extension of private capacity, a number of large units went into service at federally owned plants as well as others built by cooperatives. Among the former was the second, third and fourth 125,000-kw units at the Johnsonville steam plant of T.V.A., where two more units of like capacity are now in course of erection.

Data compiled by the Edison Electric Institute would indicate that something more than six million kilowatts of new private central station capability was added during the year making the total now installed approximately 81 million kilowatts of which more than 70 per cent represents steam power. Estimates based on Federal Power Commission figures would raise this total slightly. The total capability now on order, including publicly owned plants, approximates thirty million kilowatts.

Electrical production by private electric utilities for 1952 as reported to the Edison Electric Institute, was slightly over 399 billion kilowatt-hours which was about 8 per cent in excess of that of 1951.

The Federal Power Commission figures indicate an installed capacity among industrial power plants of around fifteen million kilowatts and a combined output of industrial and utility power plants of about 457 billion kilowatt-hours. The average central station coal rate is given as 1.09 lb per net kw-hr as compared with 1.13 a year earlier. In only one section of the country was an acute shortage of power experienced during the year. This was in the Northwest which is largely dependent on hydro power as its major supply. Here for a period, drought forced a cut of ten per cent in firm industrial power.

Abroad, the year saw the completion of a number of power plants built with Marshall Plan funds, as well as those privately financed but employing much American built equipment.

Power for Atomic Energy Projects

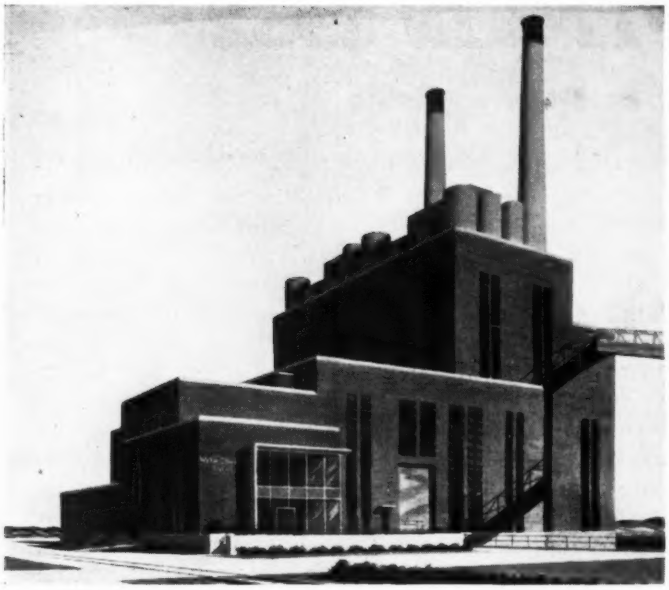
The program of the Atomic Energy Commission, aside from extensions to the World War II plants at Oak Ridge, Tenn., and Hanford, Wash., includes a large project at Paducah, Ky., announced two years ago but still in the construction stage and since doubled; another on the Savannah River in South Carolina; and a third for which ground has been broken near Portsmouth, Ohio. Because of differences in the processes, some of these will require more power than others but their combined power requirements are estimated to top eight million kilowatts, part to be supplied by T.V.A. and part by huge privately owned power plants built especially for this purpose.

Although Oak Ridge already has a large amount of installed power capacity it also takes energy from T.V.A. A somewhat similar situation it is understood will apply to the Savannah River project. Paducah will be supplied jointly by T.V.A. and Electric Energy, Inc., the latter an organization formed by a group of five utility companies which are now completing construction of the Joppa Power Station. All power for the Portsmouth project will be furnished by two plants to be built by the Ohio Valley Electric Corp. which was formed by a group of fifteen private utility companies having a combined five per cent equity with the remaining 95 per cent of the cost represented by funded debt.

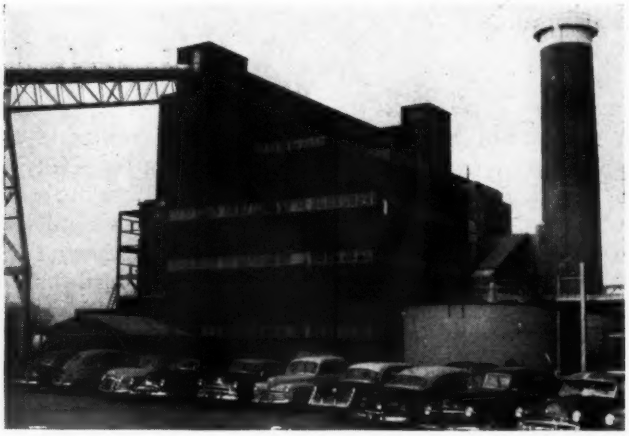
Latest available figures for Oak Ridge place present requirements at 950,000 kw with planned expansion expected to call for a total of 1,900,000 kw.

The new steam stations of T.V.A. which will bear a large share of the atomic energy load, in addition to augmenting its system capacity, are (1) Kingston with eight 200,000-kw units, four of which are nearing completion and four purchased in 1952; (2) Shawnee with ten 150,000-kw units, the last six purchased in 1952; (3) Colbert with four 200,000-kw units on order; (4) John Sevier with an initial installation of two 200,000-kw units; and (5) Gallatin with two 250,000-kw units on

Some 1952 American and Foreign Steam Power Plant Installations

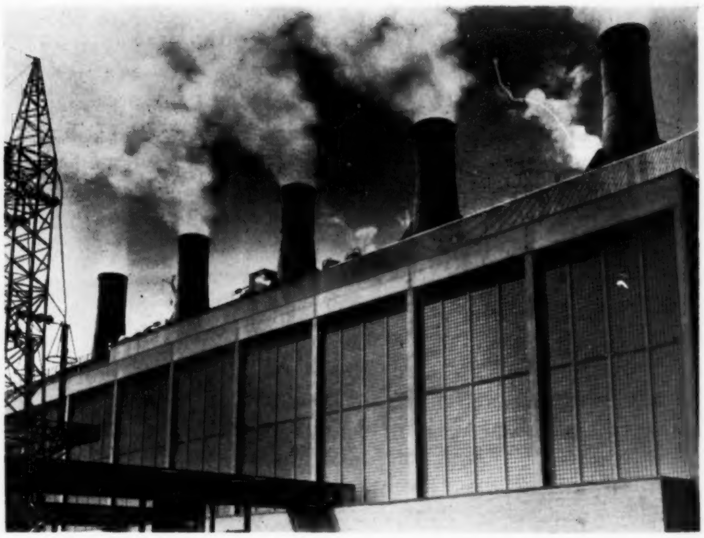


Walter C. Beckjord Station of Cincinnati Gas & Electric Company



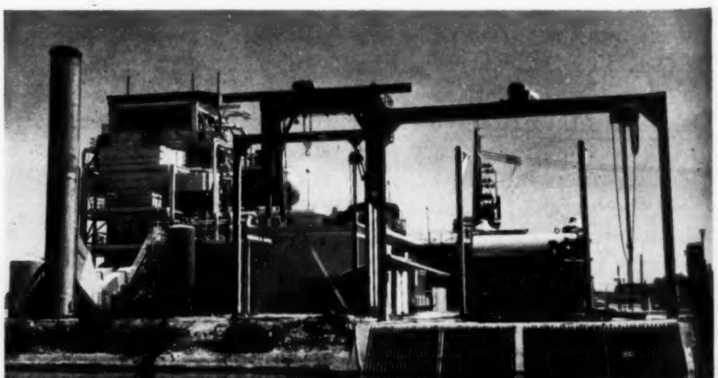
Courtesy of "Burroe News"

Greenwich Station of Atlantic City Electric Company



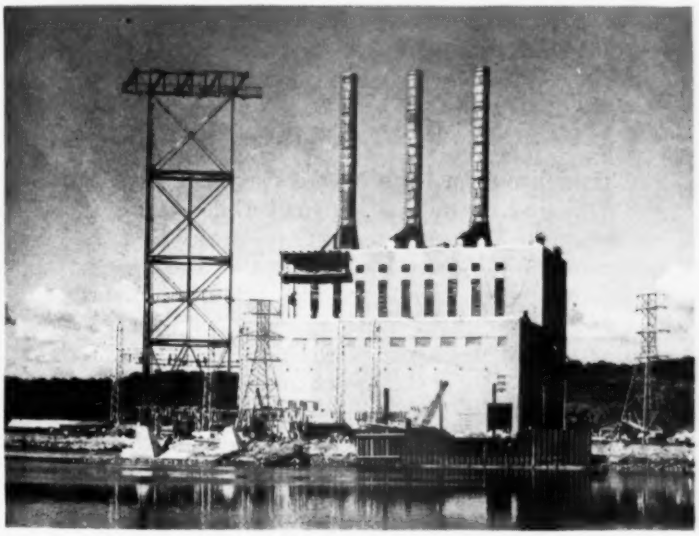
Johnsonville Steam Plant of the Tennessee Valley Authority

Black Dog Steam Station of the Northern States Power Company

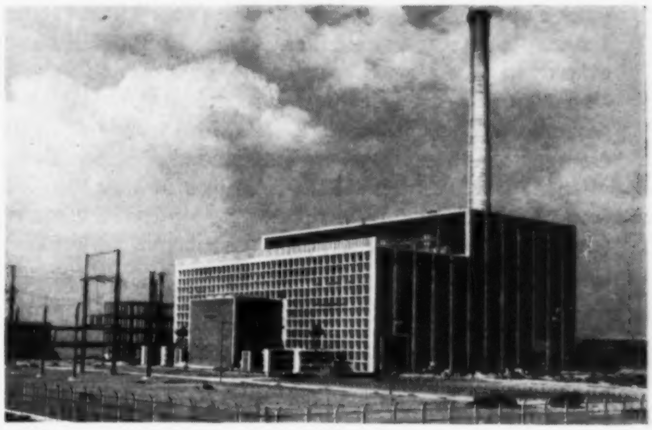


Kyrene Steam Plant of Salt River Power District

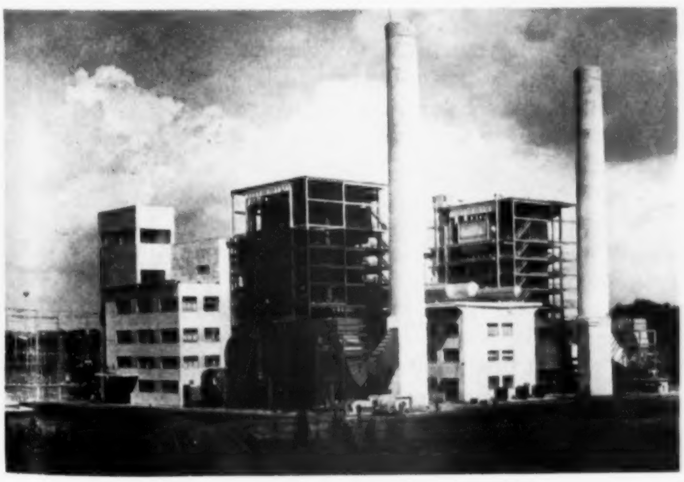
Genoa Steam Station of the Italian Edison Company



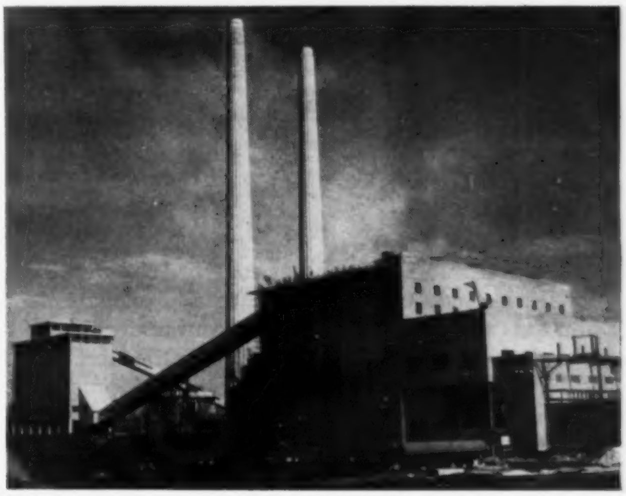
Albany Steam Station of Niagara Mohawk Power Corporation



Amer Power Station at Geertruidenberg, The Netherlands



Tavazzano Station near Milan, Italy



Dechy Power Plant at Sin-Le-Noble, Nord France

order. It is of interest that the Kingston, John Sevier and Gallatin plants will have high-pressure, high-temperature boilers of the controlled-circulation type. These are designed for pressures of 2000 to 2150 psig and 1055 total steam temperature. It will thus be seen that the new steam capacity being added to T.V.A., including Johnsonville but exclusive of the two or three earlier plants, amounts to nearly five million kilowatts.

As for the privately owned plants supplying an atomic energy load, the Joppa Station of Electric Energy, Inc., will contain six 150,000-kw units, the first of which is scheduled for service early this year. One of the two power plants of the Ohio Electric Corp., near Madison, Ind., will have six 220,000-kw units, and the other, near Gallipolis, Ohio, will contain five units of like capacity.

Steps Toward Nuclear Power

This vast expenditure of steam-generated power represents input which at present must be charged principally to defense with certain useful by-products. Nuclear power on a commercial basis appears a long way off although a promising start appears to have been made and the subject is receiving intensive study.

It will be recalled that late in December 1951 the first nuclear power was generated from an experimental breeder reactor at the Argonne National Laboratory in sufficient amount to light and service the entire building. In the test work that is being carried on liquid metal is employed as the heat transfer medium; that is, the heat energy is removed from the reactor by liquid sodium which transfers it, through an intermediate heat-exchanger to a sodium-potassium secondary circuit which, in turn, serves as the heating medium in a steam generator. From there on the regular steam cycle is employed to produce power. Electro-magnetic pumps handle the liquid metals.

On the basis of the preliminary work, the Navy Department has gone ahead with two land-based prototype nuclear power plants for submarine propulsion and one of the submarines, the *Nautilus*, has already been launched. Further work, in conjunction with several manufacturers, is being carried on toward development of a larger plant capable of driving major naval vessels.

Furthermore, the Atomic Energy Commission recently announced that security clearances are to be granted to selected personnel of ten utility companies in order for these companies to become associated with the Detroit Edison Co. and the Dow Chemical Co. in their joint study of development of a nuclear reactor to produce power. The private power companies are reported to be financing their own research work.

Fuels

Mine output of bituminous coal for 1952 was estimated by Bituminous Coal Institute to approximate 465 million tons which was about 13 per cent under that of 1951. The drop was due largely to two months steel strike last summer and to a falling off in overseas shipment of coal. Consumption by the electric utilities was around 102 million tons. It is estimated that when the power plants supplying the atomic energy projects, previously mentioned, are completed they will add about 23 million tons annually.

No figures are available as to the fuel consumption of industrial plants that is chargeable to power, inasmuch as process and heating claims a large part of industrial fuel.

Excellent performance was reported for installations employing high-set suspension burning with spreader stokers for both low volatile coals and wood refuse and the number of such installations increased appreciably during the year just passed.

An unusual installation, from the standpoint of fuel utilization, is the Sandow Station of the Texas Power & Light Co. which is being built to burn dried pulverized lignite initially under three 800,000-lb per hr boilers and lignite char when the low-temperature carbonization plant is completed. Electric energy from this station will supply a large aluminum plant of the Aluminum Company of America at Rockdale, Tex.

Another intersting plant, from the fuel-burning angle, is the Wm. J. Neal Station of the Central Power Electric Cooperative, near Minot N. D., which went into service last June. Here also pulverized lignite is being burned under two 230,000-lb per hr boilers.

Oil production in Alberta is continuing to increase at a rapid rate and gives promise of supplementing California oil on the Pacific Coast.

Natural gas is now being pumped from western Texas to the San Francisco Bay area and lines in the East are rapidly being extended.

Gas Turbines

Although only a little over three years have elapsed since the first central station gas turbine unit went into service in the United States, activity in this field of power generation in indicated by the fact that there are now in service, under construction or on order for stationary service eighteen such units ranging in capacity from 3500 to 15,000 kw. The largest of these is being built for the Public Service Co. of Oklahoma and is expected to go into operation in 1954. Five will utilize the simple open cycle with thermal efficiencies of around 16 to 18 per cent; one will employ the regenerative cycle and the remaining twelve will operate on the compound cycle with efficiencies around 26 per cent. Inlet gas temperatures range from 1350 to 1500 F.

During the year a 5000-hp gas turbine was tested for driving a compressor in gas line pumping. It was equipped with a regenerator and showed 20 per cent efficiency.

Late in the year the Army Engineers Corps ordered a 5000-kw railway mounted gas turbine-generator as part of a complete mobile power plant.

In the marine field in this country gas turbine application has been confined to small vessels, principally for some naval auxiliaries.

Abroad the gas turbine got an earlier start as a result of which there are numerous installations in both the stationary and transportation fields, the largest single unit now in service being rated at 27,000 kw. Inlet gas temperatures, however, are somewhat lower than those employed in this country.

A most comprehensive Gas Turbine Report, of 114 pages, covering design factors and existing applications in the automotive, railroad, marine, aviation and stationary power plant fields has recently been issued by the American Society of Mechanical Engineers.

*Industrial Power Plant Construction Costs**

By T. A. FEARNSIDE† and F. C. CHENEY††

This presents three simple factors, which when applied to readily obtainable purchase costs of major equipment items permit rapid and reasonably accurate determination of the major portion of total project costs for an industrial power plant.

AN engineer is frequently called upon during preliminary discussions with management to provide a quick estimate of the total cost of a proposed power plant. This is comparatively simple in the case of a utility station, for which costs may be predicted on a "dollars per kilowatt" basis. The industrial plant, however, cannot be measured by the utility yardstick.

It is the purpose here to present a set of simple factors which, when applied to readily obtainable purchase costs of major equipment items, will permit rapid and reasonably accurate determination of the major portion of the total project costs for an industrial power plant. These factors take into account all such variables as process steam requirements, special turbine steam extraction or back-pressure conditions, and current market price levels.

Utility power plant installations, while not standardized in any absolute sense, appear highly standardized when compared with the infinite variety of industrial power installations now functioning in the United States. In most utility power installations, with any given steam conditions, the size of the boilers bears a definite relation to the number of kilowatts being generated, and the number of feeders leaving the generating station proper is usually small. In industrial installations, installed boiler capacity usually bears no relation whatsoever to the number of kilowatts being produced, since only rarely do such plants use condensing turbines with uncontrolled extraction for feedwater heating. The usual industrial installation which has turbine-generators as well as boilers, involves controlled extraction turbines, sometimes with condensers on the exhaust end and sometimes without and, if condensers are used, their size bears no necessary relationship to the kilowatt rating of the turbine they serve. In addition, any amount of process steam may be provided for by means of boiler capacity over and above the steam requirements of the turbines.

In view of these circumstances, it appears obvious that any attempt to arrive at industrial power plant cost must be subdivided, and that consideration must be given separately to boiler plant, turbine plant, and condenser equipment if used. There is a fairly definite relationship between the kilowatt rating of the turbine-generators and the total capacity of main power switchgear installed with them, and such switchgear may consequently be considered, from the standpoint of cost, as a part of the turbine plant.

It has been the writers' experience that the better known manufacturers of boilers, turbines, condensers and switchgear are able to provide on short notice quite accurate estimates of the current purchase costs of boilers, industrial type turbine-generators, main power switchgear and condensers. The general description and rating of each of these major equipment items would be known in the light of steam and power requirements for a given project. Furthermore, it seems a reasonable hypothesis that the total cost of all the elements entering into power plant construction, including field labor, would bear a more or less constant relationship to the market prices of the major equipment items cited above. If this relationship can be derived from known costs of completed projects, and if for varying types of plants it does indeed remain roughly constant, one has ready at hand a factor or a series of factors which will provide a means for estimating industrial power plant costs, comparable in simplicity of application to the familiar "dollars per kilowatt" measure used for utility stations.

Range of Plants Studied

The factors developed to substantiate this hypothesis are based on a study of completion costs of ten industrial projects of varying types and sizes. All conventional types of firing were represented, including pulverized coal, oil, spreader stoker, gas and certain combinations of more than one fuel. Generating steam conditions ranged from 275 psi saturated to 1300 psi, 900 F and boiler sizes ranged from 80,000 to 450,000 lb per hr. One project involved a small boiler with no turbine-generator while another included three large boilers and two turbine-generators. All turbines were special machines, with sizes ranging from 2000 to 40,000 kw. While most were of the controlled-extraction condensing type, a few were straight back pressure. The project completion dates with one exception ranged from 1946 to 1952.

Basically, each factor consists of a multiplier by which

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* Presented at the Annual ASME Meeting, November 30–December 5, 1952.
† Mechanical Engineer, Stone & Webster Engineering Corp.
†† Electrical Engineer, Stone & Webster Engineering Corp.

a single manufacturer's estimated purchase cost may be increased to obtain an approximate erected cost of that portion of the total project which is directly related to the major equipment item concerned. Three factors are presented covering, respectively, boiler plant, turbine and switchgear, and condensing system. Each factor may be used alone or in any combination, and after application to appropriate manufacturers' estimating prices will produce a total installed cost, including all indirect charges, for all boiler, turbine, condenser and electrical equipment items.

It should be recognized that, due to wide variation in individual cases, useful factors cannot be worked out to cover certain cost items, one or more of which will nearly always be found in industrial installations. Such items include:

(*A*) Amount of excavation and piling, and special foundation conditions.

(*B*) The amount of yard piping required. Industrial projects often include yard piping systems extending far beyond what would normally be considered the "battery limits" of a utility power installation.

(*C*) The amount of yard electrical feeder runs, which is just as unpredictable as yard piping systems.

(*D*) Large or special water-treating plants, which must sometimes supply more than normal boiler makeup requirements.

(*E*) Buildings, which vary from complete enclosures for turbines and boilers to completely outdoor stations.

(*F*) Other yard installations such as circulating water intakes, coal and ash-handling systems and oil storage facilities.

(*G*) Air compressors which supply process requirements over and above power plant needs, and refrigeration equipment which may be required for air conditioning.

This means that after the factors have been applied to produce a total cost for mechanical and electrical equipment installed within the station proper, it will still be necessary to add estimated sums to cover the station building and foundations, and any special facilities required.

Boiler Factor

The boiler factor was developed from completed job cost data by dividing the erected cost, including indirect charges of all mechanical and electrical items deemed to be a part of "boiler plant," by the total purchase price of the boiler components proper.

The erected "boiler plant" cost items include:

Complete boiler unit including economizers, burners, air heaters and boiler supporting steel.
Draft fans, duct-work and stacks.
Pulverizers, coal scales, chutes and within building conveyors, but not including coal bunkers which are part of the building.
Heat-exchanger and pumps with drivers.
Tanks installed within building or on the roof.
That portion of all station auxiliary electrical equipment which pertains to boilers and boiler auxiliaries, including motors, station service switchgear and transformers, cable, conduit and miscellaneous electrical accessories.
Valves and piping associated with the boiler.
Instruments, controls and gage boards associated with boiler equipment.
Insulation, equipment painting and preliminary operation costs.

The purchase price of the boiler components referred to includes only:

Boilers, including water-cooled furnaces.
Superheaters.
Economizers where used.
Air heaters where used.
Burners.
Interconnecting duct-work between above items.
Stokers, including overfire air systems where used.
Pulverizers without chutes or coal-air piping.
Main supporting structure normally furnished to support the boiler as a part of the boiler contract.
Casings and buckstay systems for above components.
Refractory and insulation materials for all the above. The erected price of this particular item was used, as boiler manufacturers normally quote this item erected even when quoting the rest of the components without erection.

The following tabulation shows the boiler factors obtained on each project investigated together with certain other basic information relating to each:

Job	Date	Boiler, Number and Size, Lb per Hr	Pressure and Temperature	Firing	Boiler Factor
C	1946	1–80,000	250 lb, sat.	Stoker	3.40
E	1942	5–120,000	400 lb, 675 F	P.C.	3.84
B	1948	1–200,000	400 lb, 700 F	Stoker	3.25
A	1948	2–100,000	650 lb, 650 F	P.C.	3.62
F	1949	5–175,000	850 lb, 750 F	P.C. and Gas	3.54
G	1945	3–300,000	1250 lb, 900 F	Oil, Gas	3.61
D	1950	2–450,000	1250 lb, 900 F	Gas	3.64
Weighted average, projects A to G, inclusive					3.61
J	1950	2–250,000	400 lb, 750 F	Gas	2.80
K	1949	1–300,000	1250 lb, 900 F	Oil, Gas	2.45

The last two projects listed, which have been omitted in determining the weighted average factor, cover the installation of additional boilers in large existing boiler houses where most major auxiliaries had been installed on prior jobs. They are special cases and serve to illustrate the fact that these derived factors cannot be used blindly and that in unusual cases engineering judgment will be required.

Turbine Factor

The turbine factor was developed in similar manner by dividing the erected cost, including indirect charges, of all mechanical and electrical items considered to be a part of the turbine-generator and main power switchgear installation, by the total purchase price of the turbine-generator and the main power switchgear. None of the projects used included any large step-up transformers such as those often found in utility projects. The portion of station service switchgear and transformers included in the total erected cost figure is only that portion considered chargeable to the turbine generator.

The condenser and its auxiliaries do not enter into the derivation of this factor in any way.

The erected "turbine and switchgear" cost items include:

- Complete turbine-generator unit including oil coolers, air or hydrogen coolers, duct-work, and oil filtering system.
- Station crane.
- Turbine support exclusive of excavation and piling.
- Gland seal water tank.
- Valves and piping associated with the turbine.
- Instruments and controls associated with turbine-generator and main power switchgear.
- That portion of all station auxiliary electrical equipment associated with the turbine-generator, including part of the station service gear and transformers, with conduit, cable and miscellaneous accessories.
- Insulation, painting and preliminary operation chargeable to turbine-generator.

The turbine and switchgear purchase price includes only the turbine-generator with exciters, oil coolers and air or hydrogen coolers, plus the main power switchgear, without any station service gear or transformers.

The tabulation below shows the turbine factors obtained for each project investigated:

Job	Date	Pressure and Temperature	Number, Size and Type	Factor
L	1949	200 lb, 500 F	1–2 mw, auto extr. cond., .6 kv	1.91
E	1942	400 lb, 675 F	2–7.5 mw, induc. extr. cond., 6.9 kv	1.54
J	1950	400 lb, 750 F	1–30 mw, auto extro. cond., 13.8 kv	1.53
A	1948	650 lb, 650 F	2–5 mw, auto extr. cond., 4.2 kv	1.51
G	1945	1250 lb, 900 F	2–10 mw, back pressure, 13.8 kv	2.16
K	1949	1250 lb, 900 F	1–10 mw, back pressure, 13.8 kv	1.76
D	1950	1250 lb, 900 F	1–40 mw, auto extr. cond., 14.2 kv	1.54
Weighted average, projects A to L, inclusive				1.69

Condenser Factor

The condenser factor was developed by dividing the erected cost, including indirect charges, of the condenser system including the condenser with tubes, circulating water and condensate pumps, air jets, circulating water piping to station wall, screens and that portion of the auxiliary electrical work properly chargeable to condenser auxiliaries, by the purchase price of the condenser, tubes, air jets and pumps with drives. The results were as follows:

Job	Date	No. and Size	Factor
A	1948	2 @ 4000 sq ft	1.74
D	1950	1 @ 37,500 sq ft	1.89
E	1942	2 @ 12,100 sq ft	1.80
J	1950	1 @ 32,500 sq ft	1.90
L	1949	1 @ 2500 sq ft	1.64
Weighted average, projects A to L, inclusive			1.86

Other Project Costs

As has been stated, the sum of the costs arrived at by the use of the factors outlined will not represent the total cost of a project, since no allowances have been included for the highly variable items of building, foundations and any special facilities. Anyone familiar with the variety of requirements applying to these portions of a project will realize the utter impossibility of making general statements concerning them. It seems probable, however, that very fair approximations can be made by the engineer, in a particular case, based upon his own experience. Building costs, for example, may range from $0.65 to $1.20 per cu ft, depending on the type of construction and the extent to which equipment is housed.

Although no attempt has been made to find a definite relationship where probably none exists, it may be of interest to note that in reviewing the projects investigated and selecting the one most nearly representing an average industrial job, the application of the average factors to purchase costs of equipment results in an estimated figure representing about 75 per cent of the actual total job cost.

Conclusion

We have derived average factors, namely, 3.61 for boilers, 1.69 for turbines and 1.86 for condensers, which, when properly applied and when supplemented by good engineering judgment as to the cost of the miscellaneous additional items, should be of some assistance in making necessary estimates. It is obvious that the foregoing factors have a narrow base, and that similar investigation of many more projects should be made to substantiate the conclusions reached. It would be extremely interesting to compare the results of this study with similar results obtained by another investigator, working independently with a new group of plants.

It should be borne in mind that the factors presented result from recent work of the authors individually and, therefore, are not necessarily an expression of opinion of Stone & Webster Engineering Corp., by whom the authors are employed.

Facts and Figures

More than two thousand years ago Chinese blacksmiths were employing coal to forge tools and weapons.

•

Canada produces approximately 90 per cent of the world's nickel, the total output of which for 1952 is estimated at 315 million tons.

•

According to American Petroleum Institute, last year's domestic demand for petroleum approximated 2,650,000,000 bbl.

•

It takes 175 carloads to ship a million-pound-per-hour boiler.

•

Industrial plants in the United States are reported as spending $120,000,000 annually on smoke abatement and air pollution control.

•

Powdered limestone is sprayed on the roof and walls of coal mines to dilute dust and thus lower the explosion hazard.

•

The first of twenty-eight 5000-hp gas turbines is now in service in gas-line pumping on the El Paso gas transmission system.

•

The U. S. Chamber of Commerce states that, despite competition from public power, private electric utilities will soon be providing twice as much electricity as they did on V-J Day.

•

A committee of the National Physical Laboratory (Great Britain) reports that the total radiation from the sun received per day in England during the summer is greater than that received in India. This is due to the longer summer day in England.

•

The installed capacity of electric utility generating plants in the United States has increased sixfold in the last thirty years.

•

The largest steel-plant boilers to date are rated at 650,000 lb of steam per hour and serve 60,000-kw turbine-generators.

•

To date 556 electric power projects have been granted certificates of rapid tax amortization by the Defense Electric Power Administration. These projects represent an estimated total of $1^1/_2$ billion dollars.

•

Some of our strip coal mining operations in the Middle West employ huge electric-powered walking drag line excavators for removing the overburden that have booms up to 235 ft in length and 30-cu yd buckets. They would be capable of digging from a pit 120 ft deep and depositing a 45-ton load on top of an 8-story building.

•

Water shortage in the Northwest, due to drought conditions, has seriously curtailed hydroelectric power which, in turn, has resulted in severe cut-backs in aluminum smelting operations.

Meteorological Aspects of Air Pollution Control*

By O. K. ANDERSON

U. S. Weather Bureau, Louisville, Ky.

Atmospheric stability, instability and inversion are defined and their relation to dispersion of contaminants is explained, as is also the effect of turbulence and topography. It is recommended that meteorological studies precede plant location where there is reason to expect that obnoxious air pollution may result. Also, suggestions are offered for making such surveys.

In general, the atmosphere has the ability to absorb comparatively large quantities of pollution before dangerous concentrations occur. It is only under certain meteorological contions that the ability of the atmosphere to disperse pollutants is reduced to a level ranging from aggravating to possibly dangerous concentrations. The following briefly outlines some of the atmospheric processes which produce the greater concentrations in local areas and suggests some of the problems that meteorologists believe require additional study.

Atmospheric stability is one of the most common terms used in a discussion of air pollution problems, particularly in explaining the meteorological aspects of those conditions producing the most severe concentrations. To present a somewhat simplified definition of stability—the usual relationship of temperature and altitude is such that in dry air, the temperature decreases approximately 1 deg C with each 100 meters increase in altitude. A temperature decrease of less than this value indicates a stable atmosphere, and a temperature decrease greater than this value indicates instability. The condition of temperature increasing with altitude, rather than decreasing, in the lower layers of the atmosphere, is defined as an *inversion.* No change in temperature with increasing height is defined as an *isothermal* layer.

One of the most important characteristics of a stable atmosphere is that the temperature will either increase with height, or that the decrease of temperature with altitude, usually referred to as the lapse rate, will be less than the adiabatic which can be defined as the thermodynamic process during which no heat is communicated to or withdrawn from the body or system concerned. In this process a descending body of air undergoes compression and adiabatic heating, while an ascending air parcel experiences expansion and adiabatic cooling.

Falk (1) has briefly outlined stability as follows: "The pressure of the atmosphere decreases with height so that raising any parcel of air to higher levels will cause expansion and cooling along the adiabatic lapse rate without any appreciable gain or loss of heat in the surrounding air." For example, if we select a mass of air and move it upward, it will cool along the adiabatic lapse rate. At any point along this path, the displaced portion of air will have expanded and cooled and become heavier than the surrounding air. Thus the mass of air will tend to sink back to its original point of origin. Similarly, a downward movement of a parcel of air will cause compression and heating and it accordingly will be lighter than the surrounding air at the lower level. This will oppose the downward movement and the mass will tend to rise and return to its original position.

Stability Defined

A condition of stability can therefore be defined as one in which portions of air moved upward or downward will tend to return to their original levels. The typical flow pattern in a stable atmosphere is such that the fumes and smoke tend to remain at or near the level of discharge, encountering opposition to upward or downward dispersion. Thus the accumulation of atmospheric pollutants is associated with stable air layers. In a condition of instability, the atmospheric lapse rate indicates a more rapid decrease in temperature than that represented by the adiabatic value. A given portion of air moved upward will expand and cool along the adiabatic line. At a given height, the displaced mass will be warmer and consequently lighter than the surrounding air and it will continue to rise, and not, as in the case of stable air, return to its original position. Similarly, if a parcel of air is moved downward, it will become cooler and heavier than the surrounding air, and will continue to fall.

In a case of instability, there is no tendency for displaced air to return to its original position. In such a case, the lapse rate will eventually, by lateral movements, assume the adiabatic pressure-height relationship. A discharge flow pattern one might expect in such an unstable air, indicates vertical movements of the air in an effort to attain the adiabatic lapse rate. These will cause discharge pollutants to break up into several portions depending on the vertical movements of the air at the time of discharge. It can, accordingly, be seen then that unstable air will assist in the dispersion of atmospheric pollutants.

Heating and cooling of the earth's surface are among the principal means whereby variations in atmospheric stability near the ground are induced. The following illustrates a daily lapse rate cycle that one might expect due to solar heating and radiational cooling: At sunrise nocturnal cooling of the earth's surface has resulted in the establishment of an inversion and stability in the lower layers. Above this, one can assume an adiabatic lapse rate. After sunrise, solar radiation produces heating of the ground which is imparted to the overlying air and within a period of two or more hours, the inversion layer is gradually destroyed. As surface heating continues, the lower layer of air continues to heat up until the lapse rate becomes unstable resulting in vertical currents which eventually extend up beyond the top of the previously established inversion. Similar conditions will continue throughout the day until solar heating decreases to the point where radiational cooling becomes dominant.

Near sunset, the cooling of the ground is imparted to the air layers above it. Eventually, nocturnal cooling is sufficient to re-establish the inversion. Discharge of pollutants into the inversion layer during the night will tend to accumulate within that layer. As stability is decreased during the day, these pollutants will then be dispersed into deeper and deeper atmospheric

* From a talk before the Air Pollution Control Association of America at Louisville, Ky., Sept. 18, 1952.

layers. To complete the cycle as stability is re-established, pollutants are again confined to the low atmospheric levels.

A common term used in discussion of air pollution problems is atmospheric turbulence which may be defined as the rate of mixing of adjacent air layers perpendicular to the air flow. Turbulence in the air is generally the result of two major causes: (1) The movement of air over a rough surface and (2) the state of atmospheric stability. In a stable inversion layer, work must be done to mix layers above one another since the natural tendency is for each portion of air to return to its original position. Thus, in a stable atmosphere, the tendency is for turbulence to be limited to shallow layers. In layers with normal lapse rates, very little work is required to mix vertically adjacent layers so that the same amount of work supplied by the wind in the inversion case will cause turbulence in a much deeper layer. In an unstable air, once vertical mixing begins due to air moving over rough terrain, the unstable air will increase turbulence. It may be briefly stated that for the same amount of work supplied by the wind in producing turbulence over a given terrain, greater vertical dispersion will result as the stability of the atmosphere decreases.

Variations in Turbulence

Turbulence frequently also undergoes marked differences in intensity in the course of a 24-hr period. As described by Hewson (2) (3), solar heating produces a surface layer of air with a large lapse rate and marked turbulence. The upper boundary of this turbulent layer gradually extends upward. When it reaches the plume of smoke of limited vertical thickness which has been flowing since the early morning hours in the stable air, the smoke is diffused rapidly downward and reaches the ground in high concentrations nearly simultaneously with the points beneath the plume. Upward diffusion of the smoke commences as the height of the turbulent layer continues to increase and the ground concentrations fall off exponentially thereafter. Although the duration of peak concentrations at the ground is limited—of the order of $^1/_2$ hr—their magnitude is subsequently greater than those which occur with steady meteorological conditions.

Topography also has a pronounced effect on the diffusion of pollutants in many areas. In the Los Angeles region for example, both the nearby mountain ranges and the nearby ocean have pronounced influence on the winds and lapse rates and hence on the distribution of pollution in the area. Under stable air conditions in valleys, the tendency toward stagnation with an accumulation of pollution is especially marked. Such accumulations may reach dangerous values. For the first five days of December 1930 (2), weak anti-cyclonic conditions persisted over northwest Europe with a resulting accumulation of pollution in the Meuse River Valley in Belgium from the industrial city of Liége. A large number of people suffered from respiratory troubles and on December 4 and 5, 63 died. Under similar meteorological conditions (4), a large accumulation of pollution occurred in the Monongahela River Valley during the last week of October 1948. During this period 23 persons died at Donora, Penna., and its immediate vicinity.

Rough Terrain Produces Eddies

We have mentioned the effect of topography (3), although strictly speaking this is not a meteorological factor, but the effect of rough terrain on air flow and diffusion near the surface is so marked that topography must be considered. Over rough country marked meteorological turbulence may be induced and affect diffusion significantly. Under some conditions, large scale mechanical eddies of a semi-permanent nature may be caused by pronounced features of the terrain. Such large-scale eddies are especially noticeable in valleys. In addition, the lateral diffusion of pollution in a valley is limited by the valley's size, and higher concentration will develop than over a plain under corresponding meteorological conditions. In the Los Angeles area (5) (6) (7), inversions are present about 260 days a year of which some 65 are marked inversions.

The meteorologist is frequently called upon for answers to an existing air pollution problem (8). He can usually offer an adequate explanation as to the cause of the pollution concentration by drawing upon rather simple models involving lapse conditions, inversions, wind shear, etc.; but, in the past, he usually has not been consulted prior to the existence of an air pollution problem. The usual cycle (9) has involved first setting up the manufacturing establishment; next the pollution problem arises with complaints from local residents as to noxious fumes, concentrations of dust, ash, etc.; then a meteorological investigation is instigated as to the reasons and possible remedies for the pollution; and finally the plant is asked to stop operations during those meteorological conditions when the atmosphere will not act as an efficient dispersal medium. We feel that the cycle should be reversed and that preferably the plant should not be established in any location until a survey has determined that meteorological conditions in the neighborhood are reasonably satisfactory for the dispersal of airborne pollutants. In many instances, use of climatological data can be used for a determination of what might be expected in the way of pollution. Another, somewhat more unconventional method of determining the areas in which pollution concentrations would be greatest is the use of aerial photography. Those who have flown in the early morning hours have observed fog patches here and there. These normally exist in places where inversions form, which also would logically be the places where smoke would accumulate. A very few flights taken under inversion conditions should establish the areas to be eliminated from consideration if maximum accumulations of pollutants are to be avoided.

Meteorologists are frequently asked as to the effect of air pollution on such phenomena as rainfall, fog, etc. (2). In a detailed study of climate in industrial areas in England, the results clearly indicated less rainfall recorded on Sunday when the factories were closed than was recorded on other days of the week. A similar study in Germany indicated that the heavily industrialized Ruhr region gets measurable rain or drizzle on an average of 20 more days per year than do nearby less industrialized areas having comparable topography.

Air Pollution vs Fogs

A study of a long series of observations at Prague, Czechoslovakia, made at the same location, and taken under the same observational regulations, indicates that fogs have been almost twice as frequent since 1880 as they were between 1800 and 1880. In a laboratory study of artificial fogs (10), an increase in pollution brought an increase in fog density. After the pollution level had reached that representative of a small town, there was no appreciable increase in intensity. However, there was a marked increase in duration of fog with a further increase in pollutants.

In locations where local topography is favorable to high concentrations of pollutants, such as the Donora area and adjacent communities (4), one recommended procedure is for the issuance of an alert to manufacturing interests upon the approach of an extensive and slowly moving anti-cyclone which slows indications of stagnating. This preliminary alert would be followed by a warning when the following conditions occur simultaneously for one day with no signs of improvement:

1. The stability of the valley air exceeds a predetermined, specified value.
2. Valley winds of 5 miles per hour or less.
3. Upper winds of 10 miles per hour or less.

4. Moderate to dense fog is present in the valley which continues past noon.

This procedure of curtailing or even shutting down plant operations under certain weather conditions comes under the heading of meteorological control (11). Control may mean an increase in the temperature of the effluent to be discharged, change in blower power for the stack, or even curtailment or shutdown of the polluting source. One of the most successful examples of control of this type is that of smelter operations at Trail, B. C., where operations are reduced or regulated in accordance with prevailing and expected meteorological conditions.

Stack Meteorologist

The meteorologist engaged in the specialized field of meteorological control of air pollution has occasionally been referred to as a "stack meteorologist", since his work is primarily concerned with pollutants as released from stacks of chimneys. Stack meteorology is concerned with the design parameters of the polluting sources, as well as with meteorological parameters. The stack meteorologist must know what the effluent is and its mass rate of emission, speed, temperature, and source location. He must also know the maximum allowable concentrations of the pollutant and whether this quantity is allowable for a short or long time interval. He must know the source and its operations as completely as he is expected to observe and forecast the meteorological elements, or the air pollution resultant from given polluting sources at a given time and place.

The foregoing has briefly outlined some of the meteorological aspects of atmospheric pollution. The meteorologist's knowledge of the factors governing dispersal of air-borne pollutants has increased many fold in the last two decades. The British have done an outstanding job in the use of wind tunnels to locate possible dangerous pockets of pollution in hilly country. In this country, meteorological studies of wind temperature and stability have been and are being conducted by instruments mounted at varying heights on steel towers at Brookhaven National Laboratory, the University of Washington, and other locations. Many cities in the United States, as well as industrial associations, have initiated studies designed to curtail pollution in their localities with a similar survey now in progress in Louisville. These and further meteorological studies will aid in programs in minimizing pollution. However, much additional work remains to be done. Dr. Hewson (3), in summarizing the work of the Meteorology Panel of the United States Technical Conference on Air Pollution, held in Washington in May 1950, presented the following recommendations for future action:

1. That standardization in methods of handling several aspects of the problem be achieved at the earliest possible moment, in particular, standard instruments and procedures of evaluation should be evolved and adopted for use. There is also an urgent need for adoption of a standard terminology to ensure precision in presenting and conveying information.

2. That the theoretical development of the subject be promoted in every way possible. The development of basic turbulence theory is a prerequisite for fundamental advance in the study of atmospheric diffusion and must be fostered.

3. That the problem of diffusion of effluents in a city be investigated extensively, since the pollution nuisance reaches the ultimate there. A suggested approach would be an intensive survey of pollution and the associated meteorological conditions to be made by a team which would survey ten cities, well distributed over the country, with the team spending a year in each city. Each city would be chosen as characteristic for certain features of terrain and climate. At the end the ten-year period, ten cities would have been studied in sufficient detail to permit a classification of diffusion conditions in each. It may then be possible to extrapolate the detailed conclusions to other cities with the aid of only routine measurements in the latter for comparisons.

4. That micro-meteorological and micro-climatological surveys of cities and their suburbs be undertaken by local authorities with the assistance of a professional meteorologists. Instruments of standard type should be mounted on existing radio masts at standard heights with measured values presented for standard times in standard units.

5. That whenever a meteorological survey is in progress, a continuous record of the magnitude and location of pollution should be provided to permit correlation with meteorological variables. This will require the establishment of a standard pollution index so that different cities can be compared.

6. That the U. S. Weather Bureau be encouraged to take more observations of micro-meteorological significance at its stations. Emphasis should be placed on obtaining regular observations of gradients of temperature and wind in the lowest 500 ft of the atmosphere.

7. That the organization be undertaken of existing and current literature on all phases of atmospheric pollution so that everyone may be aware of the work of those in other phases.

8. That, if possible, the relationship between wind-tunnel flow and natural atmospheric flow be established.

9. That the means by which contaminants are removed from the atmosphere be studied in detail. Is the natural cleansing process rapid enough to warrant increasing the rate of dispersal of wastes in the atmosphere? At times the atmosphere is an extremely efficient disperser of gases and aerosols. In the long run, it may be preferable to use this natural diffusing agency rather than removing contaminants at the source; with atmospheric dispersal the problem of disposal of economically worthless substance does not arise.

10. That an aerial survey of the distribution of inversion fog be undertaken. Atmospheric pollution tends to accumulate over terrain where radiation fogs are of frequent occurrence.

11. That atmospheric electricity be measured more widely.

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Preheating Combustion Air by Extracted Steam*

By DIPL. ING. S. BENTE, Dusseldorf

The preheating of combustion air by steam extracted from the main turbine is advocated to augment the usual flue gas air preheating. The thermal gain is shown as a function of the number of stages, air temperatures and ratio of preheated air to total air required by the boiler. The extracted steam for air preheating is taken off in parallel with that for feedwater heating and, in this study, is carried through the fourth stage, although the most economical arrangement in most cases would appear to be one or two stages.

The preheating of the combustion air for boilers by turbine extraction steam applied ahead of the flue gas air preheater is able to augment the gains from the regenerative feedwater heating system. A two-stage steam air preheater can provide a higher thermal gain with lower initial costs than a fifth stage of regenerative feedwater heating. The regenerative air preheating distinguishes itself from the regenerative feedwater heating by the fact that it influences the heating surfaces of the

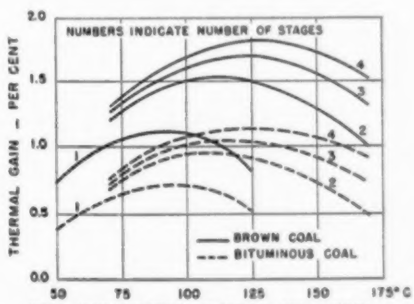


Fig. 1—Thermal gain by preheating of combustion air with turbine extraction steam

Primary steam: 1420 psig, 950 F
Ratio of air through air heater to total air: 75 per cent
Ambient air temperature: 77 F

steam generator in the opposite direction; that is, with regenerative feedwater heating the heat taken up by the water eases the load on the boiler despite an increase in primary steam flow to the turbine. This makes it possible to decrease the heating surfaces of the boiler. On the other hand, with regenerative preheating of combustion air, the heat of the turbine extraction steam is not directly transferred to the water-steam circuit and the heating surface has to be increased to maintain the same exit gas temperature and boiler efficiency.

Thermal Gain by Steam Air Preheating

As an example the thermal gains for a planned condensing power plant have been calculated with simplifying assumptions. The expansion line of the turbine in the Mollier Diagram was assumed to be independent of the extraction steam flow as a straight line, the deviation of which from the isentropic is fixed by the thermal efficiency—here assumed constant at 80 per cent. The condenser pressure was taken as constant at 1.15 in. of mercury, and the temperature difference in the steam air heater between steam condensate and hot air leaving was also assumed to be constant for all stages of extraction. Allowance was made for the heat losses of the steam air heaters by radiation. The generator efficiency was set at 98 per cent. For two or more heating stages the air preheating was divided into equal amounts on all stages.

The thermal gain, which is available through decreased fuel consumption under the assumed conditions, is plotted in Fig. 1. For this selected example the preheater provides a gain of approximately 1.1 per cent with a single stage of steam air preheating to 1.8 per cent for four stages with brown coal firing. Because the curves are flat at their peak, a change in the most favorable final preheat temperature of about 35 deg F from the optimum—for instance, by change of loads with uncontrolled bleed points—has small influence. Turbine bleed points, in addition to those already provided for the feedwater heating system, are therefore unnecessary and it will be possible in most cases to arrange the steam air preheaters in parallel with the feedwater heaters. It is, however, of advantage to subdivide equally the preheating of the air where several stages are provided.

The thermal gain for a boiler fired with bituminous coal is lower than that for a unit of equal output when fired with brown coal, because the air flow

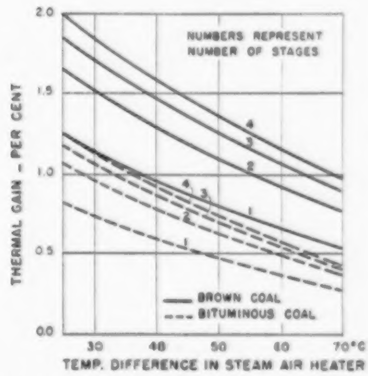


Fig. 2—Thermal gain (peaks) in relation to temperature difference in steam air heater

required for combustion and thus the fuel saving is lower.

When the temperature difference in the steam air preheaters is increased the thermal gain decreases, as shown in Fig. 2. Because initial costs are lower too, the most economical point would have to be separately determined.

Fig. 3 shows the increase of thermal gain by steam air preheating for a constant number of stages in relation to the ratio of air through the heater to total air required for combustion. Since the ratio of 75 per cent used in calculating is usually exceeded in actual installations, the thermal gain can be larger than is shown in Fig. 1.

The most favorable final temperature for air preheating is lower for a single stage compared to two, three and four stages, as shown in Fig. 4. Increasing the final temperature of the steam air preheating at highest thermal gains

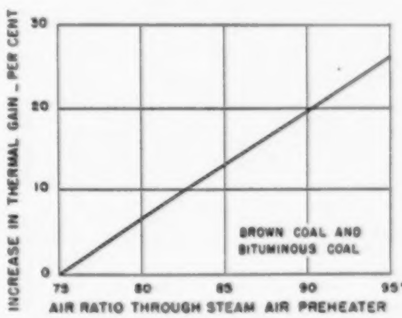


Fig. 3—Increase of thermal gain (peaks) in per cent of air through air heater ratio of more than 75 per cent

Number of preheater stages: 1 to 4

* Excerpts from a paper in the German publication Brennstoff-Warme-Kraft, translated by W. W. Schroldter.

also means a larger number of stages. The increase of thermal gain, however, quickly diminishes with increasing number of stages, as shown in Fig. 5; hence the most economical arrangement of steam air heating will be reached with one or two stages.

Operational Advantages

When starting up a boiler, the flue gases pass the flue gas air preheater at a low temperature. With air entering at room temperature, the dew point can be

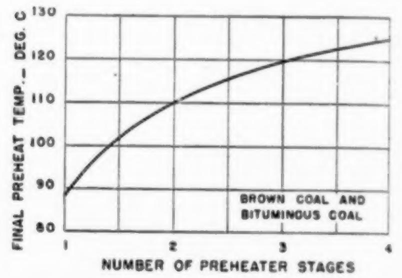


Fig. 4—Final preheat air temperature (peaks) in relation to number of preheat stages
Ambient air temperature: 77 F

exceeded, which will cause condensation and corrosion at approximately 210 F. This occurs especially when coals with high sulfur content and high moisture brown coals are used, where the flue gas dew point is higher than for low moisture bituminous coal.

This situation can be, and usually is, remedied, by recirculating part of the hot air coming from the flue gas air preheater to the inlet duct of the air preheater, which heats up the air preheater surface faster. This measure entails a loss due to the increased output required of the fan. In many cases there are also dead corners and boundary films with flue gas temperatures considerably below those of the main gas flow. For this condition recirculation does not afford complete protection.

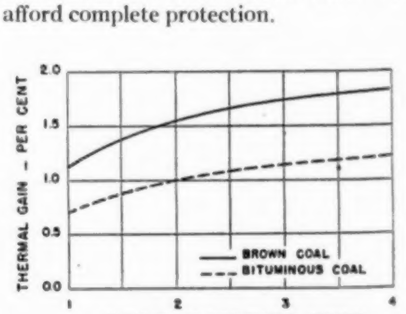


Fig. 5—Thermal gain (peaks) in relation to number of preheat stages

When a steam air preheater is provided, it can be heated with steam of higher pressure, which will very quckly heat up the following flue gas air preheater. With this arrangement temperatures below the dew point will be

positively avoided. In addition, the arrangement aids a faster starting procedure as full load steam air preheating of combustion air eliminates undercutting of dew points, especially since low exit gas temperatures, moderate feedwater temperatures and high steam air preheating make it necessary to arrange the flue gas air preheater in a higher gas temperature zone ahead of an economizer section.

Effect on Boiler and Turbine Plant

Steam air preheating therefore requires a larger heating surface of air preheater and possibly economizer; also a larger high-pressure unit for the turbine. The thermodynamic efficiency of the turbine, which is a function of the steam flow, increases in the high-pressure stage. On the other hand, the low-pressure section of the turbine, as well as the condenser, can be made smaller. The reduced steam flow through the low-pressure stage also decreases turbine exhaust losses. The higher air inlet temperature increases either the surface of the flue gas air preheater or that of the economizer.

The advantages and disadvantages of steam air preheating have to be carefully weighed to reach the optimum condition, where the possible thermal gain justifies the higher initial cost, the increased cost of maintenance and operation and the added complication of the system.

Petroleum and Natural Gas Set New Record

According to the Interior Department, the crude petroleum producers chalked up another record year in 1952 with an output of approximately 2.3 billion barrels. This was equivalent to 6,260,000 barrels daily and represented a slight increase over the figure for the preceding year. The output was worth an estimated 5.8 billion dollars at the wells, or an average of $2.53 per barrel. This petroleum output accounted for over 40 per cent of the total value of mineral production in the United States during the year.

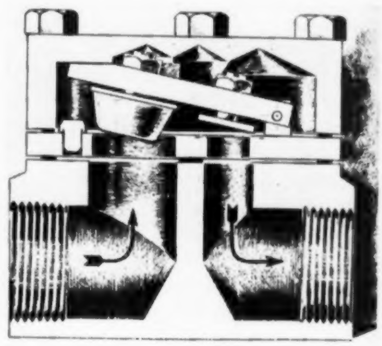
The marketed production of natural gas was estimated at 8100 billion cu ft, which was 9 per cent more than that reported in 1951. The average value of the gas at the wells rose slightly to about 7.4¢ per thousand cubic feet.

Production of natural gasoline was estimated to have risen approximately two per cent to around 121 million barrels. Moreover, the output of liquefied petroleum gases expanded by an estimated six per cent to roughly 100 million barrels.

New Equipment

Inpulse Steam Trap

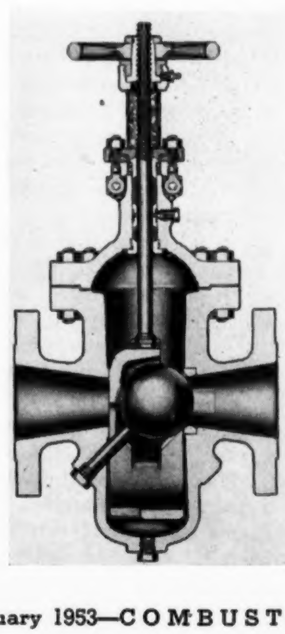
Yarnall-Waring Co., Chestnut Hill, Philadelphia 18, has developed an impulse steam trap for use where condensate must be handled in unusually large quantities. Known as the Series 50 impulse trap, it employs a hinged lever and two valves mounted on a



valve seat plate. The control flow which governs opening and closing action of the valves is obtained by allowing small clearance between inlet and outlet valves and their respective seats when the lever is at rest. These traps are available in $1^1/_2$ and 2-in. sizes and are suitable for pressures up to 300 psig.

Venturi Ball Valves

Replacement of the conventional-shaped disk with a ball is the unique principle employed in a new line of valves announced by the Crane Co., 836 S. Michigan Ave., Chicago 5. This ball is not attached directly to the stem but rides in a cage which is attached to the stem by a tee-head slotted construc-



tion. In operation the ball is moved to and from the center of flow and rolls into and out of the body seat. The ball disk is mechanically locked in the closed position by a wedging member on the cage. In moving to the fully open position, the ball rolls out and up, until it is lined up vertically with the stem and is carried out of the path of flow. The new valves are available in venturi patterns, with flanged ends, in cast carbon steel and 18—8 alloy steel, and in a wide range of sizes beginning at 1 in. Cast steel valves are available in 150, 300 and 600-lb classes, and alloy valves in 150 and 300-lb classes.

Draft Gage

Now available from The Hays Corp. Michigan City, Ind., is the Hays "Vertiscale," a draft gage having the following features: three-way atmospheric vent, simple zero check, magnetic access door, dust-tight case and fluorescent lighting with lucite scales. It is possible to mount from one to twelve units side by side in a single case, and a choice may be made among four types of mounting. The gages can be obtained with a spring-loaded metallic bellows for indicating functions such as level, flow, temperature and pressure pneumatically transmitted by other instruments. Ranges from 0.2 in. of water to 120 in. of water, draft and differential can be provided.

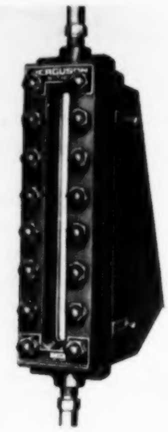
Temperature Transmitter

The Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio, has recently exhibited a new temperature transmitter which may be used in central power stations in connection with the all-electronic control system manu-

factured by that company. Known as the Type T2T Autronic Temperature Transmitter, it consists primarily of a resistance thermometer element and a thermometer adapter unit. The former is made of platinum wire wound on a ceramic core and sealed in an Inconel tube. The thermometer element is connected to the adapter unit by a three-wire system which compensates for variations in lead wire resistance with ambient temperature change.

Gage Illuminator

Jerguson Gage & Valve Co., 80 Fellsway, Somerville, Mass., has designed a new gage-glass illuminator consisting of a mercury-vapor bulb enclosed in a steel housing and a ballast



box equipped for easy mounting at a convenient spot. The illuminator clips to the gage cover with two sets of brackets, making installation easy with no alterations to the gage. It is furnished in weatherproof construction suitable for outdoor use. In operation the water column shows blue-green, topped with an intensely brilliant emerald green at the water level, giving an unmistakable indication.

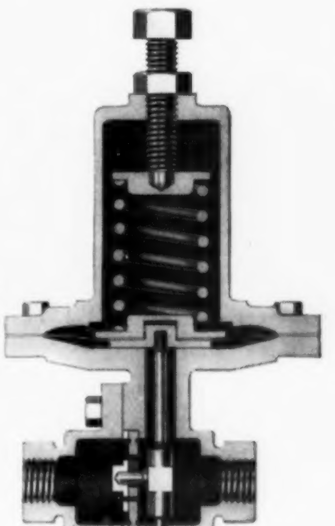
Water Level Indicator

A simple level indicator having a 12-in. dial and suitable for use in boiler rooms has been announced by The Foxboro Co., Foxboro, Mass. Large white numerals and a micrometer-type pointer against a dull black scale provide accurate reading at a distance or in dim light. This boiler-water-level indicator is available in various standard ranges from 0–20 to 0–200 in. of water, and its forged-steel body has a rated working pressure of 2000 psig.

Pressure Reducing Valve

An automatic pressure-reducing valve has been designed and made available by the Jordan Regulator Corp., 109 W. Mulberry St., Lebanon, Ohio.

Consisting of a bronze body, a stainless steel gate that slides on a plate of similar material, a phospho-bronze diaphragm and stainless steel small parts, it requires very little space and can be



installed in any position. Sizes in which the valve is available range from $^1/_4$ in. to 2 in. It is rated 150 psig at maximum steam temperature of 400 F and is suitable for inlet pressures up to 250 psig in water or air service. Reduced pressure as low as 2 psig may be provided.

New York Meeting of Instrument Society of America

A regional meeting of the Instrument Society of America is to be held at the Penn Top suite of the Hotel Statler, New York City, on February 18, 1953. On the program will be technical sessions covering instrumentation for process industries, pharmaceuticals and power plants. The principal speaker at the session will be H. S. Bean of the National Bureau of Standards whose subject will be "Future Research and Development in Fluid Metering."

Papers of specific interest in the power plant instrumentation session, of which the Chairman is Joseph Lewis of Combustion Engineering-Superheater Inc., are as follows: "Taking Superheated Steam Tube Temperatures in Boilers" by T. W. Jenkins, Jr. of Leeds & Northrup Company; "Television in the Power Industry" by J. C. Parker, Diamond Power Specialty Corporation; "Gas Analyzers and Air Flow Measurement for Combustion Control" by C. H. Barnard, Bailey Meter Co. and "Combustion Control for Multiple Fuels" by M. J. Boho, Hagan Corp.

He Asked Permission to Stay

Major William E. Barber, USMC
Medal of Honor

IT WAS DURING the Chosin Reservoir withdrawal. Eight thousand weary marines lay besieged at Yudam-ni; three thousand more were at Hagaru-ri, preparing a breakthrough to the sea. Guarding a frozen mountain pass between them, Major Barber, with only a company, held their fate in his hands. Encirclement threatened him; he was ordered to withdraw. But he asked permission to stay, and for five zero-cold days the company held the pass against attack. The Major, badly wounded, was carried about on a stretcher to direct defense. When relief came, only eighty-four men could walk away. But Major Barber's action had been decisive in saving a division.

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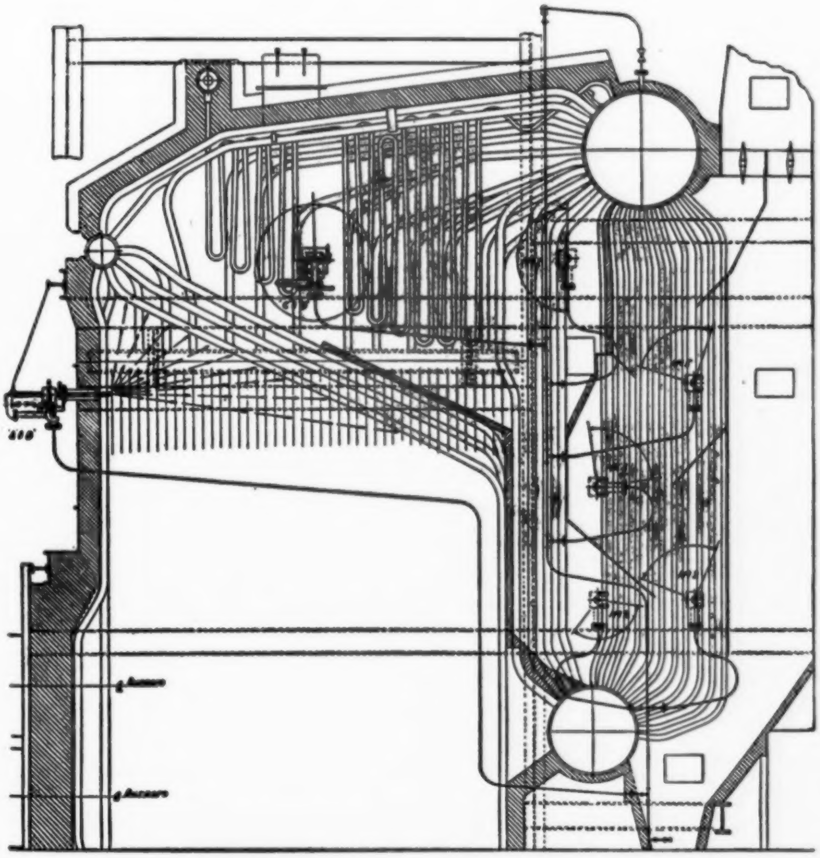

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BOOKS

1—Fuels and Combustion Handbook

Allen J. Johnson, Editor and George H. Auth, Associate Editor

915 pages Price $12.50

The objective of this practical handbook is to bring together for ready reference representative factual material on fuels and combustion. Much of this information heretofore had to be searched for in pamphlets and articles scattered throughout the trade press and in publications of government bureaus and engineering societies.

More than 450 major references were used by the editors in compiling the handbook. It is estimated that 50 per cent of the material is less than five years old and over 80 per cent less than ten years old. The scope is sufficiently broad to interest fuel technicians, engineers and operating men.

The handbook is characterized by an unusually large number of tables of data and by the extensive use of alignment charts for rapid computations. The nomograph method of computing heat balances has been presented in quite some detail.

There are eight sections in the handbook, covering solid fuels, liquid and gaseous fuels, combustion, fuel selection, coal preparation, fuel-handling methods, heat transfer and steam generation, and test procedures. Many recent developments in the broad field of combustion are discussed, including those associated with synthetic fuels, the heat pump, gas turbines, and spreader stokers. One very interesting chapter is entitled "Factors Involved in the Selection and Purchase of Fuel."

2—Radiation Monitoring in Atomic Defense

By D. E. Gray and J. H. Martens

122 pages Price $2.00

Current interest in civilian defense programs makes this book especially timely. Part I is devoted to background information on atomic and nuclear energy and the hazards that are produced during and after an explosion. Much of this section can be understood by readers with no technical background. Consideration is given to protective measures and to means of measuring and detecting nuclear radiations.

Part II takes up instruments and equipment in radiation detection. It describes the basic construction and characteristics of a number of specific radiation detection devices and gives instructions for their operation and maintenance.

3—Steam and Gas Turbines

By B. G. A. Skrotski and W. A. Vopat

395 pages 6 × 9 Price $6.00

As might be expected from the relative use and state of development of the two types of prime movers, about 80 per cent of the text is given over to steam turbines and 20 per cent to gas turbines.

Intended primarily for operating engineers, the book is informative to anyone in the power field and might well be employed as a reference text for students, despite the absence of problems.

An elementary approach is employed in describing turbine types, followed by descriptions of commercial machines in greater variety than found in most other books on the subject. There follow chapters on lubrication, turbine governors, auxiliaries, maintenance and performance. The illustrations are simple and helpful.

Under gas turbines, descriptions of the simple cycle and closed cycles include a discussion of means for increasing efficiency through intercooling, reheating, etc. The same approach to the subject is employed as in the preceding chapters in steam turbines.

4—Sourcebook on Atomic Energy

By Samuel Glasstone

546 pages Price $3.40

Following a request of the American Textbook Publishers Institute for a comprehensive sourcebook on atomic energy this book was prepared by Dr. Samuel Glasstone at the instance of the Atomic Energy Commission. It brings together important facts about the past history, present status and possible future of atomic science. While the work has been termed a "primer" on the whole subject of atomic science, the very complexity of the topics under discussion makes for some difficulty in reading and comprehension. On the whole it is written in language as simple as is compatible with the subject.

Throughout the book a historical approach is used wherever possible to describe the growth of thought and knowledge in the atomic field. Some mathematical expressions have been found necessary to explain certain atomic developments, but most of the equations are intelligible to those with a knowledge of algebra.

An idea of the scope of the book may be had from the following representative chapter titles: Constituents of the Atom, Natural Radioactivity, Nuclear Radiations, Isotopes, Nuclear Transmutation and Artificial Radioactivity, The Neutron, Nuclear Fission, The Utilization of Nuclear Energy, The Uses of Isotopes, Cosmic Rays and Mesons, and Radiation Protection and Health Physics.

5—Steam Plant Operation Second Edition

By Everett B. Woodruff and H. B. Lammers

542 pages 6 × 9 Price $7.00

This book, originally brought out in 1935, is aimed at presenting a practical text for the guidance of engineers engaged in operating stationary steam plants. It provides basic information on the combustion of fuels, types and certain construction details of fuel-burning equipment, boilers, their settings and auxiliaries; also steam engines and turbines together with their auxiliaries. Moreover, considerable space is given to the safe and efficient operation and maintenance of steam plant equipment. At the end of each chapter is a list of questions, with specific text references as to where the answers can be found. This feature should be of great assistance to those preparing to take examinations for an operating license.

In the present edition the text has been largely rewritten to bring it up to date as regards present designs of equipment and current practice.

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